JOURNAL

OF THE

Association of Engineering Societies

St. Louis St. Paul Oregon

CONTENTS AND INDEX

VOLUME 55

July to December, 1915

PUBLISHED MONTHLY BY
THE BOARD OF MANAGERS
JOSEPH W. PETERS, SECRETARY
3817 OLIVE ST., ST. LOUIS, MO.

CONTENTS.

Vol. 55. July—December, 1915.

For alphabetical index, see page IV.

INDEX.

Vol. 55. July---December, 1915

Abbreviations—D.=Discussion; I.=Illustrated.
Names of authors are printed in *italics*.

GEORGE W. RATHJENS,

President, Civil Engineers' Society, of St. Paul.

WILLIAM S. TURNER,

President, The Oregon Society of Engineers.

Editors reprinting articles from this JOURNAL are requested to credit the author, the JOURNAL OF THE ASSOCIATION, and the Society before which such articles were read.

ASSOCIATION OF ENGINEERING SOCIETIES

ORGANIZED 1881.

Vol. 55. JULY and AUGUST, 1915. No. 1

This Association is not responsible for the subject-matter contributed by any Society or for the statements or opinions of members of the Societies.

THE EAST SIDE LEVEE AND SANITARY DISTRICT

By T. N. Jacob,*

Member of The Engineers' Club of St. Louis.

[Read before the Club, June 2, 1915.]

The East Side Levee and Sanitary District is the legal name given to the drainage district organized in December, 1909, to provide sanitation and flood protection for the following defined territory:

The boundaries of the district embrace an area of 96.36 square miles, all of which is low ground and which is a part of what is known as the American Bottoms, extending from a point two miles north of the village of Mitchell to Prairie Du Pont Creek on the South, a distance of 18 miles. The boundary lines do not at all times follow fixed topographic features, but generally speaking, the Western boundary is the left bank of the Mississippi River and the Eastern boundary the Bluffs. The cities in the District are East St. Louis, Granite City, Madison and Venice, and the villages of Cahokia, National City, Brooklyn, Nameoki and Mitchell.

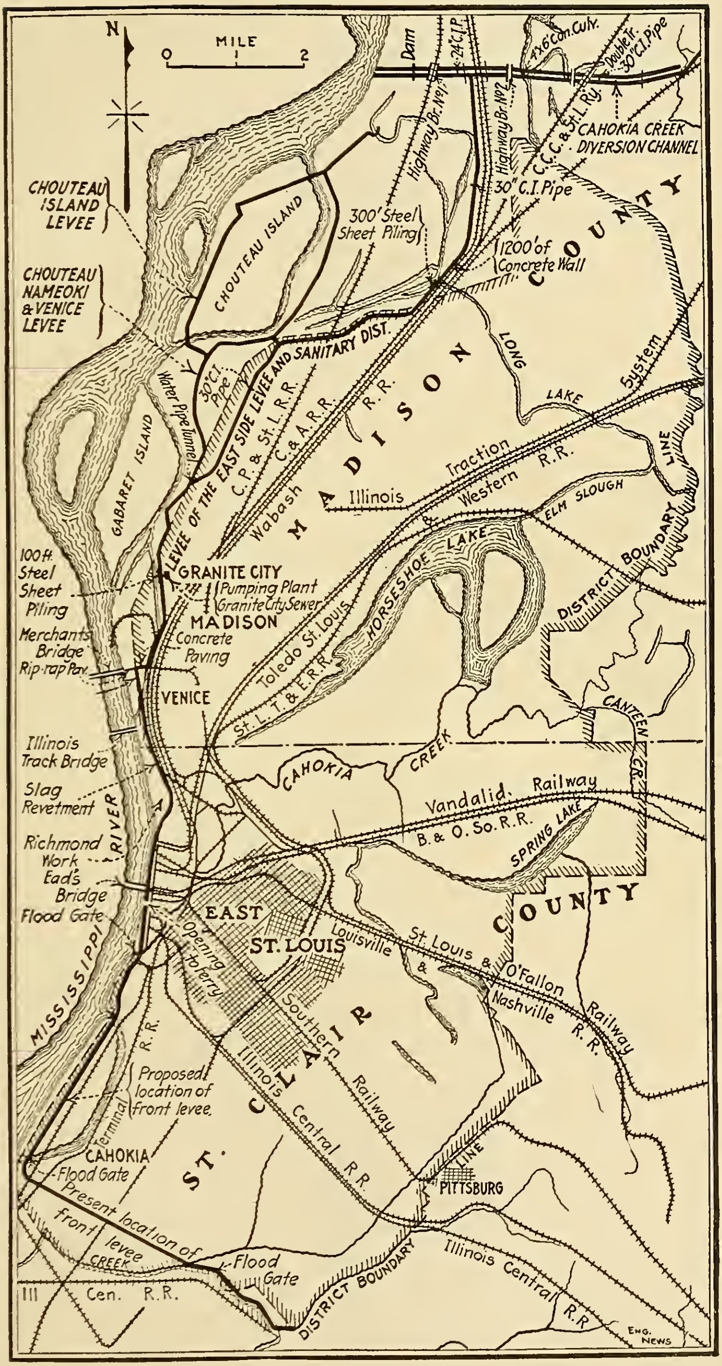
Because of the fact that all of the ground in the District is lower than the flood plane of the river, it was necessary to build

*Consulting Engineer, East St. Louis, Ill.

levees. It was also necessary to provide satisfactory facilities to take care of the surface water of a large drainage area and to supply means for passing the water of the local streams through the levee. The largest and most important of the local streams are Cahokia Creek, which has its source near Litchfield, and the Prairie Du Pont Creek. The former has a catchment area of 382 square miles and the latter one of 65 square miles, making a total of 447 square miles of drainage to be taken care of.

The matter of flood protection and drainage was given desultory attention ever since the advent of the first settlers. Many ditches were dug and quite a number of levees were thrown up, but no comprehensive scheme was started. No plan having as its aim and purpose the final settlement of all East Side flood and drainage problems was evolved until the flood of 1903 centered public attention on the urgent necessity of establishing a complete and adequate system. Virtually all of the levees of that time were inadequate and were destroyed by the 1903 flood, which was second only to the flood of 1844. This impressed on the inhabitants of the district the necessity of establishing a comprehensive system of levees of sufficient dimensions to protect them against the maximum flood conditions.

Mass meetings were held, plans discussed, investigations and reports made by Government officials and discussions carried on in the press. Out of this came the East Side Levee Association, an organization of business men, who gave freely of their time and money. A fund of $25,000 was raised to develop a permanent organization properly empowered to handle all phases of the situation. A Board of Engineers consisting of Col. O. H. Ernst, Maj. T. G. Dabney and Maj. Harrod, and known as the Ernst Board, investigated and reported favorably on the proposition, as had also a Board of U. S. Army Engineers. The report of the Ernst Board was used in preparing a bill that was enacted into law by the Illinois General Assembly giving the necessary powers to meet the conditions. This was followed in December, 1909, by the election of a Board of Trustees. This Board appointed Col. J. A. Ockerson, Consulting Engineer, and the writer Chief Engineer. The Engineering department immediately proceeded to collect data. A topographic survey, covering 127.5 square miles, was made, and from the data thus collected a topographic map was prepared on which are shown contours, two feet apart in elevation, and all natural and artificial features. From



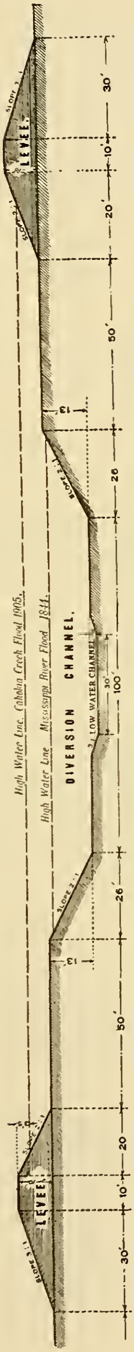
Map of the East Side Levee and Sanitary District, Showing Boundary Line and Flood Protection Works.

permanent points established by the Mississippi River Commission base and control lines were established, with transit and tape. Topographic features were located by stadia. Elevations were determined by wye levels. All important lines were checked by repeating. The true geographical positions of all important points were found by careful calculations, and in this manner field errors were located and corrections made.

While the surveys were in progress, studies were made from which was prepared a GENERAL PLAN OF SANITATION which was adopted by the Board. All of the construction work done has been based on the lines of this general plan. The estimated cost in this general plan was $6,500,000.

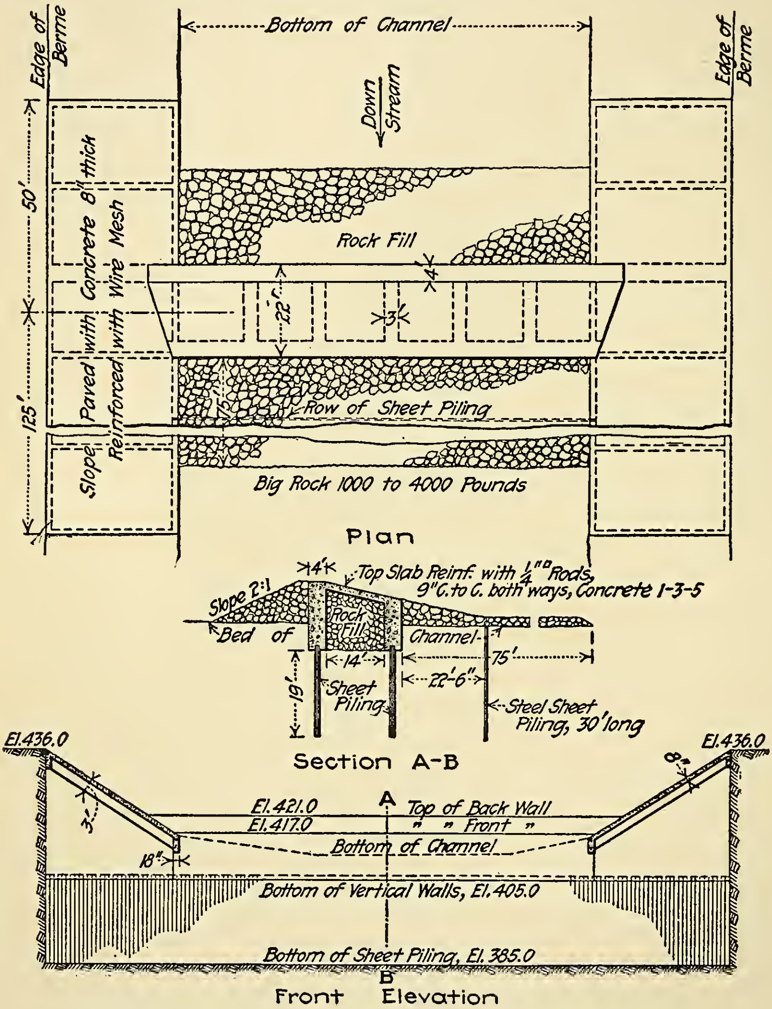
Diversion Channel.

Cahokia Creek Diversion Channel diverts the run-off from 259 square miles of its drainage area. The Ernst Board seriously considered this plan, but did not recommend it, because, as a member of an Army Board, Col. Ernst had previously recommended the construction of a canal from near the Merchants' Bridge to Alton on the Illinois shore, which such a diversion channel would intersect. Maj. Dabney told the writer a few months ago that he was glad the plan was changed so that this diversion could be made. The Ernst plan proposed a channel for Cahokia Creek by enlarging the old channel, and, following a more direct route from near Poag to near Monks Mound, and from there to Prairie Du Pont Creek, a new channel 300 feet wide on the bottom; Prairie Du Pont Creek, also, was to be straightened and enlarged. The proposed channel was to have levees on either side to take care of back water. The Cahokia Creek Diversion, as adopted and built, is 4.5 miles long, 100 feet wide on the bottom, has a slope of 2.0 feet per mile, and a vertical drop of 9 feet, one-half mile from river. The "drop" is necessary because the shorter distance to the river by the new channel made it impossible to utilize all of the available fall in slope. The channel is crossed by nine bridges,—five railroad and four highway. The material excavated was used to construct a levee on each bank, 50 feet from the edge of the cut. The South levee forms the North levee of the District, which is extended to the Bluff. The contract price on the earthwork was 16.95 cents per cubic yard. One contractor, with six drag line scrapers, took out 1,500,000 cubic yards in nine months. The cost of all bridges was borne



Cross-Section of Cahokia Creek Diversion Channel, Four and One-Half Miles East of River.

by the District, as under the Illinois law the railroads are not required to build bridges over new channels, but by agreement with the District the railroads will maintain them. The railroad bridges are of the girder type; the C. P. & St. L. and the C. & A. have



Check Weir and Drop, Cahokia Creek Diversion Channel.

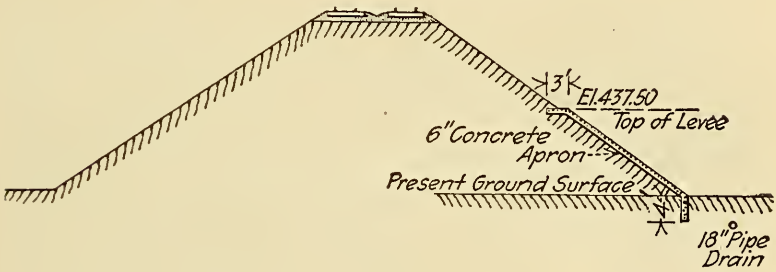
concrete decks; the wagon bridges have concrete floors. All the bridges have concrete piers and abutments supported on pile foundations. The total cost of this channel was, in round numbers,

$900,000. About 25,000 acres have been reclaimed and the drainage problems of the District are much simplified.

The 25,000 acres of which I speak are those South of the channel. The Diversion Channel by diverting the head waters of the creek to the Mississippi River eliminates the creek as a flood menace and permits the land to be cultivated continuously, which of course greatly enhances its value.

Levees.

The standard specifications for the levees are: Crown, 8 feet; river slope, 1 on 2; land side, 1 on 3. The slope of 1 on 2 for the river side was adopted after it was decided to revet this slope with a concrete slab 4 inches thick. The purpose in changing from the Mississippi River Commission standard of 1 on 3



Levee with Reinforced Concrete Apron, Merchants' Bridge Approach.

was primarily to decrease the amount of concrete slab required. The height is further increased 2 feet above the grade line by a topping of this amount that is rounded off. The standard requirements of selecting material, preparation of base, and a muck ditch are followed. As yet funds are not available for building the concrete slab, but a very good bluegrass sod has been provided.

At Mitchell, owing to very limited space and other topographic conditions, a concrete wall serves as a flood barrier. I am pleased to say that the C. & A. Railroad Company gave the Trustees the right of way for this wall. From the Diversion Channel to the north end of the wall at Mitchell, and from the south end of the wall to a point about ¾ mile above the Merchants' Bridge approach, the levee is built of material borrowed from the side;

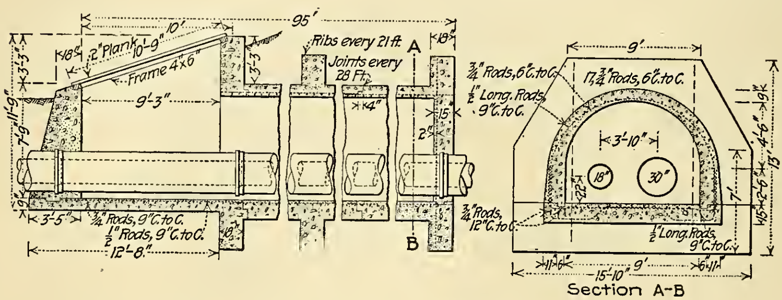
the balance, south to the Wiggins Ferry Company's property, is built of clay, hauled in by train. On the section built by side borrow method the usual specifications were followed; the clay fill will be described later. The team work cost from 11 to 18 cents per cubic yard, according to local conditions.

Drainage Through Levees.

In all cases where drains pass through the levees they are provided with automatic gates on the river side and hand power gates on the land side.

Water Mains.

The Granite City Water Supply pumping station is outside of the levee on the river bank. The force mains leading to the distribution system pass under the levee and are enclosed in a concrete tunnel, closed on river side by a concrete wall and open on



Concrete Tunnel Through Levee, for Granite City Water Mains.

the land side. Should a break occur in the section of main under the levee the water would pass out of the tunnel without damage to the embankment.

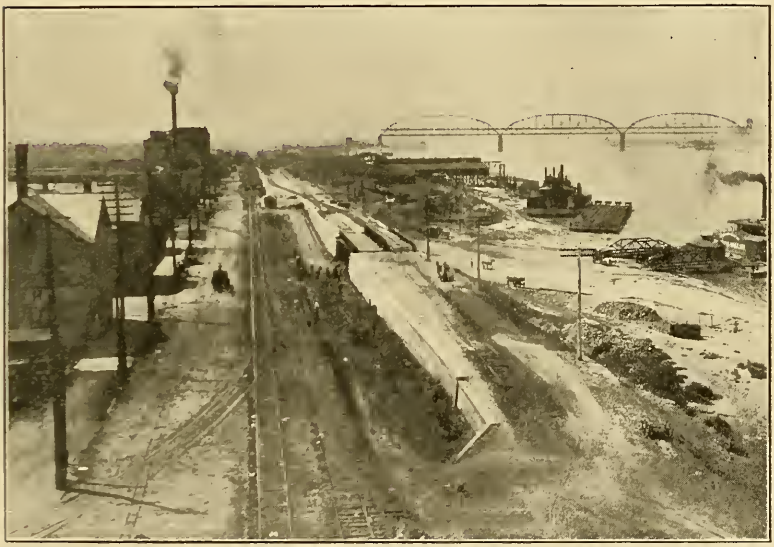
Clay Fill.

Clay from the bluffs was chosen for this section of levee for three reasons. First, there was no side borrow material available. Second, the quantity of material and section made the hydraulic method impracticable. Third, satisfactory material convenient to the railroads was available at several points that made competition keen. The clay was obtained on the Big Four Short Line, about 20 miles from the levee, and was loaded by steam shovels on 30-yard air dump cars. A pile trestle was built along the center line of the levee, the cut-off being 3 feet below grade. Spreading was done with a locomotive spreader

and the slopes were completed with teams and scrapers. This work cost 48 cents per cubic yard.

Revetment.

As stated, the concrete slab has not yet been applied to the levee, but the Merchants' Bridge approach embankment, that serves as part of the levee, has been protected up to the grade line of the levee with a concrete slab that is very satisfactory. The first 500 feet of the levee from the bridge approach is reveted with limestone riprap and on the balance, down to the Wiggins Ferry property, furnace slag is used. This slag comes in pieces ranging



River Front Levee, East St. Louis, Ill.; View Taken from Eads Bridge; St. Louis Municipal Bridge in Distance.

from ½ inch to 6 inches in size, is much heavier than limestone and does not disintegrate. About 50 per cent of the material is foundry sand. A trench about three feet deep is dug at the toe of the levee and filled with slag. The slope is covered to a depth of two feet. This is a waste product of the foundries and it is furnished free to the Trustees at the foundry. The railroad delivers it for $1.00 per car on tracks owned by the District, on top of the levee; unloading and spreading is all done by hand, the cost of the completed revetment being about ⅓ that of limestone riprap.

The Levee of the Wiggins Ferry Company.

The levee protection on the property of the Wiggins Ferry Company, by an agreement entered into with the Trustees, is being done by this Company and is a part of a reclamation scheme by which all of their land along the river is brought above ordinary flood level and also protected from maximum floods.

The method is as follows: A pile bulkhead is driven and filled with heavy stone, about 24 feet inside of the outer harbor line. The top of the bulkhead is 3 feet above the low water mark. Beyond this there is a willow mattress 80 feet wide, weighted down with stone. These form the protection for the toe of the new embankment, which is made of material pumped from the bed of the river by an electrically driven hydraulic dredge. The Government requirements are that there shall be no structure between the harbor lines extending above the harbor slope, which is 30 feet on 250 feet, or one on eight, approximately. The slope is protected by limestone pavement, nine inches thick, on a covering of crushed stone, 4 inches thick. The inside slope is made very flat and is occupied by railroad tracks. The levee section here is much in excess of the usual section. The section built by the Wiggins Ferry Company is about 3 miles in length and will cost about $1,600,000. The south end is on the right bank of Cahokia Creek. From this point to the tracks of the Southern Railroad, about 600 feet, the District built the levee of clay from one of the quarries near Falling Springs, and also constructed a temporary timber culvert which is divided in 3 vertical compartments, each 7 feet by 16½ feet, provided with steel flood gates, which are hung vertically and close and open automatically by the water pressure. No pumps have as yet been installed. The plan is, to first build the levees and then follow with the drainage ditches and pumps as funds become available.

The Trustees will soon let contracts for the completion of the levee in the lower portion of the District and will follow as funds are available with the work of draining and correcting any unsanitary conditions that may exist. (Bids for the remaining portion of the levee were opened early in July. This section, amounting to about 800,000 cubic yards, extends from the mouth of the Cahokia Creek to the southern boundary of the District, a distance of three and one-third miles. This will be built of

clay, hauled in by train, an average distance of about ten miles. The lowest bid was 36 cents.—Ed.)

So far about $4,000,000 has been expended. The funds are raised by bond issues which are paid from moneys received from a tax levy on both personal and real estate property; this now amounts to nearly $400,000 per year.

[Note—Further discussion of this paper is invited, to be received by Joseph W. Peters, 3817 Olive Street, St. Louis, for publication in a subsequent number of the Journal.]

BOILER FAILURES AND WHAT THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS IS DOING TO PREVENT THEM

By E. R. Fish,*
Member of The Engineers' Club of St. Louis.

[Read before the Club, June 16, 1915.]

The use of vessels for generating steam under pressure is, of course, as old as the use of steam itself, and for just that long there have been boiler failures of different kinds. Beginning with low pressures, imperfect and ill-suited materials, mediocre workmanship, and unscientific designs, the art and practice of boiler making has steadily progressed. We are, however, still far from perfection as is evidenced by the continued disasters of varying magnitude.

Much has been written on the subject of boiler explosions, but Prof. R. H. Thurston was the first to put the subject in concrete scientific shape, and from his writings I quote freely, for he expresses conditions far better than I possibly can. He gives the following principles:

1. "That steam boiler explosions are always the result of well understood causes and are only mysterious, in any case, in the sense that available evidence may not point out with certainty which of the various well known causes may have operated in the given case.

2. "Boiler explosions are always preventable. It is always practicable to so design, construct and manage steam boilers that there shall be absolutely no danger of explosion.

3. "That the proper course on the part of the designer, builder and user is to first use forms of boilers, wherever practicable, such that, as Col. John Stevens said a century ago, 'their explosion shall not be dangerous even should over-pressure occur.' The same idea was enunciated by Fairbairn. Insure next good and well tested materials, good and well inspected workmanship and uniformly skillful management by men of experience and reliability. Regular, effective and thorough inspection constitutes a part of good management and an essential part. 'Steam boilers are magazines of energy forcibly restraining explosive powers of such magnitude as few can compute or realize.'"

*Vice-President and Secretary of the Heine Safety Boiler Co.

As an example I select from one of the tables he calculated covering a number of different types and sizes of boilers, a return tubular boiler of sixty horse-power working at 75 lbs. pressure. The weight of such a boiler is approximately 9,500 lbs., the water it contains weighs 8,200 lbs., and steam 21 lbs. The available stored energy in the water is 50,008,790 foot-pounds; in the steam, 1,022,730 foot-pounds, or a total of 51,031,520 foot-pounds, which is sufficient to project the boiler only to a height 5,372 ft., with an initial velocity of 588 foot-pounds per second.

Quoting further from Thurston:

"It is seen that the energy stored in the steam boiler, in the form of heat, is mainly that of the heated water and comparatively little resides in the steam; so that it follows that a boiler well filled with water is vastly more dangerous in case it explodes, than if exploded as a consequence of low water. * * *

"Comparing the energy of water and of steam in the steam boiler, with that of gunpowder, as used in ordnance, it will be found that, at high pressures, the former becomes possible rivals of the latter. Taking the value of gunpowder at what the writer would consider a fair figure, 250,000 foot-pounds per pound, it is seen that a cubic foot of heated water, under a pressure of 60 or 70 pounds per square inch, has about the same energy as one pound of gunpowder.

"A powder magazine under one of our modern tall buildings, or under the sidewalk in Broadway, would be objected to very seriously by citizens compelled to make that great thoroughfare their daily walk, and if compelled to submit to its threatening presence, they would certainly insist upon the most stringent precautions being taken to insure safety against the liberation of its stored energy; but scores of steam boilers are so concealed and the laws of the city and state relating to their care are of the most lax and ineffective character.

"Good design, good workmanship and good management have been said to be the three safeguards against destructive explosion. Good design, in any case, presupposes a well read, well educated, and an experienced designer.

"Good construction involves the selection of good materials and their proper use in building the boiler. This means, in turn, iron, or more commonly steel in which ductility and toughness, rather than simple strength, are the special characteristics, and

perfect uniformity in the several sheets of which the boiler is made up. Good construction involves the exact production of the required forms of parts and their riveting, or welding, together without loss of strength or introduction of stress. Good management means the regular and moderate firing of the furnace, constant inspection of the parts liable to corrosion or other injury, and maintenance in as perfect condition as possible by constant repairing of injured parts. It also includes the periodical inspection and test which now constitute the basis of insurance.

"All failures are due to preventable and familiar causes that might be evaded by the designer, the builder or the operator. Whatever may be said of the many known and possibly unknown, the certain, the probable and the possible causes, mysterious or otherwise, of boiler explosions, it is certain that a boiler is practically safe for all time in the hands of a good engineer or fireman if originally well designed, well constructed and properly set. Its safety is assured by a correct system of inspection either on the part of the person in charge or of the official inspector or, more usually and properly, of both working together honestly and in good faith. A correct system of inspection is the check upon every defect of design, of construction and of operation.

"Inspection should be made at fixed regular intervals, should be conducted by an inspector experienced, reliable, of good judgment and absolutely conscientious. He should be accompanied in his inspection by the responsible man in charge of the boiler, and his examination should be deliberate, thorough and unimpeachable. The time should be so chosen that the work may be done satisfactorily, without haste or interruption. The method should be—careful examination by eye, hand and a light hammer, of every sheet, stay, brace, tube and rivet in the boiler. Defective riveting, the most common defect, should be looked for in every seam. Cracks in the seam, under the lap, are not unusual and are very difficult to find in many cases, but if undiscovered they will be likely to prove disastrous. Corroded sheets and tubes, bad bracing, sediment and incrustation are all promptly detected and readily visible in any case. The thickness of thinned sheets, corroded on either side, or of blisters, may be judged by the action of the sheet under the hammer, and many defects, entirely invisible, are found by the experienced inspector by the hand and ear, reinforced by the use of this tool. It is evident that no inspection worthy the name can be made unless with the boiler dry

and empty, and accessible in every part. A design which does not permit this should be condemned offhand. Tests by hydraulic pressure, though useful, and in the judgment of the writer, indispensable, cannot be, in any case, allowed to supersede the real inspection above outlined.

"Whatever may be the fact, however, more perfect and effective methods of inspection must be legally introduced and well enforced before the steam boiler explosion can become extinct, with its resultant destruction each year of hundreds of lives and millions of dollars' worth of property. With such methods, universally practiced, steam boiler explosions will become unknown."

Written some 20 or 25 years ago the advice thus given has been to a considerable extent followed, but there still remains much to be accomplished, particularly as regards proper state legislation.

There are approximately 1,500 explosions of varying intensities each year in this country, averaging 400 or 500 killed and 700 or 800 injured and many hundreds of thousands of dollars damage to property.

General methods for proportioning the several dimensions of the boiler structure have long been known and in general use, although modified from time to time by tacit consent as experience or new and improved materials and methods became available. These rules, if such they may be called, have varied greatly in details in various places, depending on the personal opinions and experiences of the man or men formulating them. It can readily be appreciated that with the great multiplication of such regulations which has been going on in the past few years, manufacturers who do a wide interstate business, have become confronted with a condition that is hard to meet. In addition there are the infinite variety of private specifications written by consulting engineers and others that differ through exceedingly wide limits, and which represent the judgment of one or at best a very few men. Under such conditions it is impossible to manufacture economically, for a boiler built to meet the requirements of one place may be rejected in some other locality.

In 1905 there occurred in Brockton, Mass., an explosion which caused $250,000 damage, the loss of 58 lives and 117 injuries. This aroused the State of Massachusetts to action, the result of which was the enactment of legislation providing for the licensing

of engineers and firemen, and governing the construction, installation and inspection of boilers. A board for boiler rules was created for the purpose of formulating construction standards. Its labors resulted in the most complete, scientific and logical set of regulations that had ever been promulgated. These rules have been quite extensively copied all over the country. However, the need of regulations that would represent the consensus of opinion and experience of the whole country rather than that of any one locality, prompted Col. E. D. Meier, when president of the A.S.M.E., to appoint a committee to formulate such rules. After more than two years' work,—real work, after numerous and lengthy discussions, often heated and acrimonious,—the A.S.M.E. Boiler Code, as it is popularly known, has resulted and represents, as nearly as it is humanly possible and what those who are best qualified to know believe to be, the best boiler practice. There is much in the Code that is absolutely new. Probably only such a body could have prevailed upon certain antagonistic manufacturers of materials and fixtures to get together and agree on uniform specifications for their products. This is notably the case with safety valve manufacturers and tube makers. Possibly the most remarkable achievement is the very definite regulations relative to safety valves, most of which is entirely new. This Code covers the construction of stationary boilers and allowable working pressures, and is divided into two parts. Part 1, Sec. 1, applies to new installations of power boilers, and Part 1, Sec. 2, applies to new installations of heating boilers. Part 2, applies to existing installations. Obviously, it is necessary for considerable leniency to be extended to boilers now in use. To do otherwise would work a tremendous hardship on thousands of steam users.

In brief, the subjects covered by the Code are indicated by the sub-headings: "Selection of materials," wherein is specified what grades of materials may be used for various parts and places; "Ultimate strength of material used in computing joints," in which unit stresses forming the basis of calculations are given; "Minimum thicknesses of plates and tubes," to prevent "skinning" the job; specifications for boiler plate steel, rivet steel, stay-bolt steel, steel bars, steel castings, gray iron castings, rivet iron, stay-bolt iron, and tubes, all of course, as pertaining specifically to boiler practice. Then following under the heading, "Construction at maximum allowable working pressure for power boilers," are detailed rules for determining strengths, the efficiency of joints,

etc., with examples and stating in what way much of the work shall be executed. Then come the subjects of manholes, washout holes, threaded openings, safety valves, water and steam gauges, fittings and appliances, wherein are given methods for determining quantities, sizes, limitations as to location and kind of metals to be used. Some general regulations as to setting to promote safety in operation are given, how hydrostatic tests shall be made, and finally the method of stamping to show the conformity of the structure with the Code.

The rules covering boilers used exclusively for heating, cover substantially the same ground, but are much more brief. In Part 2, appear the rules for determining the working pressure to be allowed existing boilers, and what fittings must be provided and how applied. These will require many minor changes if the Code is followed, but there are none but what should be made in any event. This section also provides for the gradual amortization, to use a commercial and financial term, of boilers now in use and not built to the Society standard. An appendix gives full examples of various riveted joints and the method of calculation, as well as of braced and stayed surfaces and the method of computing safety valves. Also how fusible plugs should be located in the various types of boilers and standard dimension for flanged pipe fittings.

In my opinion it is amply sufficient for any one desiring to purchase a boiler plant, after having determined the working pressure and the size and type of units required, to merely specify that the boiler is to be built according to the A.S.M.E. Code. By so doing he will get from any reputable manufacturer a well constructed structure entirely suited to its purpose. If preferred, the material and workmanship may be checked by some inspecting agency. From a manufacturer's standpoint my plea is for country-wide uniformity of requirements, and this the general adoption of the Code makes possible. It couples together economical manufacturing with the all-pervading cry of Safety First.

In compiling this code, therefore, the A.S.M.E. has provided a substantial basis for specifications and legislation of all kinds. It cannot go further than to say that this is, in the estimation of those best qualified to judge, the most rational code of rules and regulations for boiler construction. The enforcement must be left to the activities of other agencies. A very considerable number of the boiler manufacturers of the country have already got-

ten together on two occasions; first, on September 19, 1914, and again on March 29, 1915. The avowed purpose of these meetings was to further the universal use of the Society's Code, and at the last named meeting it was unanimously endorsed and steps taken to launch a movement to prevail upon the various states to enact legislation to put the Code into legal effect. It seems impracticable to do this in any other way. The State of Ohio has already done so. The State of Wisconsin will, in all probability, do so to be effective January 1, 1916.

Educational movements will have to be started in various other states, in order to be at all sure of any success at future state legislative sessions. Last fall it was hoped that the Code would be completed in time to present the matter definitely to the numerous legislatures that were in session early this year, but that proved to be impracticable. One of the forms of education is to persuade those who have positive ideas of their own that such should be subservient to this broader consensus of opinion. Only by so doing can country-wide uniformity, that is so exceedingly desirable, be attained. Already there are some objections raised to minor points which indicate that there are difficulties to be overcome in arriving at the desired end.

That this effort of the Society will help tremendously in primarily bettering boiler construction generally, and secondarily, in smoothing the way of manufacturers, thus redounding to the financial benefit of the user, needs no further argument. It has already attained such momentum as to make it a powerful factor.

It can truly be said that what the A.S.M.E. is doing to prevent boiler failures is something that could have been done by no other organization and that the effect will be far-reaching and long continued.

[Note—Further discussion of this paper is invited, to be received by Joseph W. Peters, 3817 Olive Street, St. Louis, for publication in a subsequent number of the Journal.]

THE PAVING OF STREETS

By H. J. Fixmer.*

[From Thirtieth Annual Report, Illinois Society of Engineers and Surveyors.]

The paving of streets and roads is being gradually regarded as a subject requiring expert knowledge, and not to be determined by an individual's prejudice, convenience and taxes. There are many general qualities which pavements must have to prove satisfactory. They should be designed to conform to the condition of use and provide for adequate service. General rules may be adopted and rational formulas followed, but their use must be based on reason and an observance of the peculiarities applying to the particular problem in hand. We should not adhere too closely to "standards" so-called, which, while designed to reduce work and perhaps promote efficiency, tend to eliminate freedom and thereby discourage experiment, discovery and progress.

There should be good and definite reason for every element entering into the rational design of pavements, as contrasted to the "rule of thumb" methods so commonly used. The engineer building pavements should be impressed with the fact that his work is of common use and continuously in evidence, and should therefore make every effort to secure the best results.

Reasons for Paving.

The reasons for paving the street must be explained to the general community, and must be borne in mind by the engineer when preparing his recommendations and designing the pavement. The reasons and the results to be secured therefrom are: 1. Decrease in cost of transportation (20 cents to 5 cents a ton mile). 2. Increased fire protection (speed doubled and certainty of service). 3. Establishment of a permanent grade (necessary for comfort of traveling public and for permanent construction). 4. Improvement of the general appearance and beautification of the town. 5. Improvement in sanitation, health and drainage (eliminate dust, stagnant water, etc.). 6. Facilitation of social intercourse; by rendering pleasure driving and pedestrian traffic easy and

*Division Engineer, Board of Local Improvements, Chicago, Ill.

agreeable. 7. The enhancement of property values (at least twice the cost of paving can be added to values). While these results are to be realized in city pavements, they should in great measure be sought after in the building of country roads.

Roadway Widths.

As a general policy, the length of road improved is more important than the width. This rule does not often apply to city streets. The determination of proper width of roadway is an extremely important element in design. A traffic census is often desirable, but unless it is truly comprehensive, more can be learned by direct and frequent observation of the street. A traffic census must give not only number of vehicles, but the different kinds of vehicles, kinds and sizes of tires, wheel loads, rates of speed, space required for storage and parking, and character of adjoining property.

It is customary to allow 8 ft. in width to each line of vehicle, reducing this width as shown in Table 1. Where two car tracks are built, not over 10½ ft. c. to c., 20 ft. is allowed for the free movement of the cars. Table 2 shows width and length of typical vehicles found in Chicago.

Unless the traffic exceeds or promises to exceed 5 to 10 vehicles a mile in either direction, 9 ft. width should prove ample on country roads. It is better policy to build a so-called

Table No. 1.

Width of roadway in feet	Type of street usually applied to.	No. of lines of vehicles provided for.
9	Ave. or light traffic road	1+
16-18	Side res. st. or double rdwy. sts.	2
24	Residence streets	3
30	Res. streets and business streets	4
38-42	Business and car line streets	5 (4 on car line)
48-52	Business and car line streets	7 (6 on car line)
60	Bus. and car line sts. and blvds.	8 (6 on car line)

Table No. 2.

Kind of Vehicle.	Width—Hub to Hub. Feet.	Length—Back to Curb. Front Wheels at Rt. Angle. Feet.
Delivery wagon	5.5 to 6.7	8.7
Single truck	5.8 to 6.0	11.4
Large truck	6.4 to 6.6	12.8-14.0
Newspaper truck	7.75	14.75
Touring car	5.5 to 5.8	10.0-16.0
Auto truck	6.7 to ?	12.0

"permanent" road 9 ft. wide (with 5-ft. earth shoulders on each side) than a poor road 18 ft. wide. In view of the fact that perhaps over 90 per cent of the time the vehicle occupies the middle of the road, and even in practice on the wider road usually prefers to suffer the slight inconvenience of turning out occasionally in order to ride on the more comfortable or acceptable part of the road, it appears logical to give due weight to this factor of "practical use." If a 9-ft. permanent road is built, additions can always be made whenever the traffic warrants it, and would be indicated by a traffic census or by excess cost of maintenance of the earth shoulders. When consideration is given to the habits and needs of the users of the roads, the soundness of the policy that length of permanent road is more important and desirable than width is soon appreciated.

In city pavements, the use of the streets for "storage," or rather provision for vehicles to stand alongside or back up to the curb in front of abutting property, must be considered and is a vital factor in ascertaining the rational width of roadway. Take the case of a street having many warehouses, where large trucks back up to the curb to handle goods. After finding this condition prevails on both sides of the street and that allowance must be made for two lines of moving traffic between the "standing" trucks, we would determine the roadway to be not less than two times 8 ft. plus length of truck back in position. From Table No. 2 this would give two times 8 plus 14, or 44 feet. In residence districts, where connecting streets are paved as a system, the roadway on all streets where the lots front are made 24 to 30 ft. wide and side frontage streets 18 to 24 ft. wide. The curb corners are built to a radius of 3, 6 or 8 ft.

Congested Roadways.

Perhaps the most serious condition in securing adequate roadways exists on streets having a double track car line. These are invariably business streets and require storage space for vehicles and automobiles. On such a street, providing for two lines each of street railway cars, moving vehicles and standing vehicles, we find a width of 2 (8+7+10), or 50 ft. is required. If the moving traffic is expected to use the car tracks, and the service on the street railway is infrequent, the width may be reduced to 2

(8+10), or 36 ft. A roadway width of 38 to 48 ft. in this case would be wasteful.

On a certain main artery in Chicago, where a double car line exists and the roadway is generally but 38 ft. wide, with stores continuously on each side, the delay occasioned to the passengers on the street cars by teams and vehicles turning on and off the tracks to pass standing vehicles amounts to an average of 2 minutes per mile traveled. This means that each passenger living an average of 5 miles from his work, loses twice five times two (or 20) minutes a day. Assuming a value for his time of only 30 cents an hour, the total extra loss to the car users equals the gross receipts of the street railway company. This sum capitalized indicates the sum that might be employed to reduce, or rather, remove the existing street congestion.

A street car that makes good time attracts more people and gives more time to shop, while it distributes business uniformly along the street. For this reason, when a street becomes too congested it becomes necessary to widen the street in order to secure ample roadway or place the car line on an elevated structure or in a subway. It is an extremely important question to decide whether it is better to build a subway in a congested business street or use the money to widen the street and keep the car traffic on the street surface and easily accessible.

Layout of Surface of Pavement.

The contour of the pavement surface is important. For the purpose of drainage and maintenance the pavement is built with a convex or crowned surface. Table 3 shows general or constant, maximum and minimum crown for various types of pavements,

Table No. 3.

Pavement.	General or Constant Ft.	Chicago	
		Max. Ft.	Min. Ft.
Earth	.025 to .030	......	......
Gravel	.022 to .025	......	......
Macadam	.020 to .025	.035	.020
Asphalt	.012	.025	.011
Asphaltic concrete	.015	.025	.012
Brick	.012	.025	.010
Creo. wood	.010	.024	.010
Granite	.015	.025	.010
Concrete	.010	.020	.010

as followed in Chicago. A formula for height of crown is C=WF, where C=crown, F=constant or crown ratio, and W=width of roadway.

As usually built, the surface is either an arc of a circle or a parabola. Experience has demonstrated that the parabola form is preferable for residence streets, and the "compromise" form for business or car-line streets, and particularly pavements having macadam base. Country roads can usually be built with a constant crown since they follow the contour of the natural surface and have sufficient longitudinal grade. If the grade is level, the drainage can be taken care of by sloping the grade of the side ditches. The two forms of crown noted above are proportioned as follows, C being the crown and the other figures the offsets below the horizontal line from curb to center.

	Curb	¼ Width	½ Width	¾ Width	Center
Parabola	C	.56C	.25C	.06C	0
Compromise	C	.61C	.32C	.12C	0

With city streets, which are invariably curbed, if the longitudinal grade is not sufficient to carry off the water, drainage must be provided. This is done by building sufficient sewer inlets and establishing summits between them whose location depends upon the grade of street, slope required to drain, and the permissible depths below the curb of the summits and the inlets. The following formula is given for locating summits (in the gutter): $X=(L\div 2)-(D\div 2R)$. Here X= distance of summit from higher inlet; L= distance between inlets; R= grade of gutter (6 in. fall per 100 ft.=.005); D=difference of elevation at inlets (or usually, difference of elevation of curbs). On a concrete gutter the assumed value of R should not be less than .004. For any block pavement, including alleys, this value should be not less than .005.

The following formula is given for determining depth of summit and depth of inlet below curb (or grade) to satisfy values in formula No. 2. Here J=depth of inlet below curb (8 to 12 in.); K=depth of summit below curb (usually 3 in.). The formula is $J=K+RX+(DX\div L)$ or, $K=J-RX-(DX\div L)$. The minimum crown from Table No. 3 is used at the summits, and the maximum crown is permitted at the inlets. This reduces the grade along the center line of the pavement to about one-half the gutter grade, and gives a comfortable surface for travel.

Use of the Street.

In designing the contour of the surface of a city pavement, there are the often overlooked factors of comfort and safety of the users of the pavement; both pedestrian and vehicle traffic. About ten pedestrians cross a pavement to every vehicle traveling along that street. In practically all streets (of whatever character) while the ratio may not be 10:1, yet the number of pedestrians having occasion to use the pavement in crossing the street, greatly exceeds that of the vehicles using the street. It should be rational therefore to so pave the street as to afford pedestrians the maximum degree of comfort and safety, while not interfering with the right of safety and comfort of the vehicle users. In relation to this matter some interesting, if not exceptional methods have been developed and their success established.

In retail business and residence streets it is the general policy to eliminate the usual step at all street intersections and alley returns where pedestrians cross. This is done by paving the street or alley flush with the curb in line with the continuation of the usual 6 ft. sidewalk. To drain the intersection, the catchbasin inlet at the curb corner is set 4 to 6 in, below the top of the curb. From the line of the outer edge of the sidewalk the pavement slopes on a straight line to the nearest sewer inlet. In residence districts, where there are no sewers in the side frontage streets, and the catchbasins are already built in the customary manner (at the curb corners and in the middle of the standard 600 ft. block) it is often advisable to save expense by a method originated by the writer. This consists of building a raised header in the combined curb and gutter with its top 1 in. below the curb and recessed in the middle of its top for a slab 5 in. x 6 ft. which is an extension of the adjacent 6-ft. sidewalk. The header is 6 in. thick and is so built as to make the width of gutter between the curb and header wider at the end nearest the inlet. The gutter is built with an increased slope under the slab.

The purpose of this arrangement is to render the gutter, especially under the slab, self-cleaning. The header is connected to the surface of the gutter by a reverse curve for a distance of 6 ft. on each side of the extended sidewalk, or slab cover, making the header 18 ft. long. This construction has been in use for four years, and has proved satisfactory. It eliminates the step at the crossing, covers the usual dangerous opening where a false gutter is employed, affords a dry and clean crosswalk at all times,

prevents breaking of curb through expansion of sidewalk, is self-cleaning, and has a slab cover which is not slippery and cannot be displaced. The writer secured a patent on the novel feature of this construction and has given the city of Chicago the right to use it free of any charge or royalty. At alley returns the pavement is brought flush with the top of the curbs for the full width of the sidewalk. At the end of the return, or street line, the center of the alley is dished at the rate of 1 in. per 5 ft. of width and this point connected on a straight line to the gutter line of the street proper, affording good drainage and keeping the crossing dry and clean.

The ideal solution for a business and two car line street is to bring the pavement flush with the walk of the business street at the returns for the cross streets, run the pavement surface at the gutter line to the curb corner at a depth of about 4 to 6 in. below the top of the curb; thence around the curb corner to the catch-basin inlet, located about 70 ft., more or less (depending on the grade) from the curb corner, at a depth of about 8 to 10 in. below the top of the curb. This eliminates any step for the main lines of pedestrian traffic along the business street, but does present a 6-in. step to those crossing the business or car line street. This tends to cause pedestrians to hesitate before crossing a busy street, and affords a smooth, full width of roadway for the vehicle traffic along the direction of the busy street.

Regulation of Vehicles.

"Safety first" is a popular motto and certainly applies to the public use of the street as well as to a railroad. In large cities, the police regulate the crossing of intersecting streets by both vehicles and pedestrians in the congested part of the town; but elsewhere the pedestrian must take his chance. Consideration is now being given to the probable necessity of limiting the over-all width of auto trucks to 7½ or possibly 8 ft.; to the width of tires to carry given loads, as 1 in. width per ton on each rear wheel, and to the permissible speeds of autos of various tonnage. The following table has been suggested, and when the economics of the factors involved are properly considered, some such regulation will no doubt be enforced. The necessity of limiting speeds is not only due to public safety but because of the effect of weight and impact on wearing surfaces and pavement foundations. On

country roads width of tire, speed and weight are dangerously important because of the character of roads and highway bridges.

Table No. 4.

Type of Auto	Max. Speed miles per hour	Type of Auto	Max. Speed miles per hour
Passenger auto	20 to 30	Truck— 4 to 8 tons	8
Auto bus	15 to 20	Truck— 8 to 12 tons	7
Empty truck	15	Truck—12 to 20 tons	6
Truck—Up to 2 tons load	12	Truck—20 to 30 tons	5
Truck—2 to 4 tons	10	Truck—Over 30 tons	4

Fundamentals of Construction.

The construction of roads can be divided into five principal parts, as shown in Table No. 5, which gives the comparative costs and life of the various components.

Table No. 5.

	Cost Per Cent.	Life In Years.
1. System of drainage (Sewers, inlets, ditches, culverts)	10-20	20-100
2. The earth subgrade	10-30	20-100
3. The foundation	20-40	10-50
4. The wearing surface	20-50	2-30
5. *Maintenance	5-50	

*Maintenance ought to be included as an element of cost, and, while chargeable almost entirely to the wearing surface, may operate to reduce the average cost of such wearing surface because of prolonging its life.

There are but two approved forms of foundation construction; namely, macadam (including telford) and concrete. The thickness and quality of the foundation must be based on the maximum loads to be supported, and the amount of pressure which the subgrade will bear, together with the inherent strucural resistance of the material composing the foundation. If it is assumed that 30 per cent of the total weight of a vehicle is transmitted by each rear wheel, and a 30-ton auto truck is to be provided for, then we can expect a pressure of nine tons across the area of contact of tire of approximately 9x6 in., or 54 sq. in.

In the case of macadam, the lines of pressure fall within lines making an angle of about 45° with the surface, due to the interlocking of the stones. The area distributing pressure on the

subgrade varies directly as the square of the depth or thickness of the foundation plus part of the thickness of the wearing surface. Hence a thickness of 12 in. would support on a given subgrade about four times as much as a thickness of 6 in. Since a dry, well rolled subgrade will support more than a wet subgrade, the question of adequate drainage, as opposed to increased thickness of foundation, must be considered. Design can be based on rational principles, and, if not, then it should be based on direct investigation at the site in question.

In the case of a concrete base, the failure is more likely to be due to shear than to tensile failure under beam action. The strength of a concrete base varies directly as the square of its depth. Definite information is needed as to the strength of concrete under the daily stress of use. A coefficient could be determined by experiment, by laying, say a 2-in. and a 4-in. base and subjecting them to various loads at known speeds. With such knowledge we could design more intelligently. Is a 6-in. concrete base of 1-3-6 mix on an undrained clay soil strong enough to resist the trucks; if so, with what factor of safety? If not, what is the economical thickness? It is commonly assumed that a 6-in. concrete base is equal to a 12-in. macadam base, but is this true?

Wearing Surface.

A wearing surface is really but a protection for the foundation. The foundation should be built and regarded as a permanent structure, while the wearing surface is usually selected for qualities other than durability. In all successful construction, climate, drainage, and traffic must be considered. There are many types of wearing surface, but they fall within the limits of the nine kinds enumerated in Table No. 6. This table is a condensed summary of other tables based on conditions obtaining in Chicago. Cost figures are based on the average prices bid. This table is based on the character of streets for which the type of pavement is most suitable and usually specified.

In table No. 6, the second column is derived from the values given by the U. S. Dept. of Agriculture (Circular 141), which are based on the pavement qualities of cheapness or first cost, durability, ease of maintenance, ease of cleaning, low tractive resistance, non-slipperiness, favorableness to travel, acceptability, and the most important, sanitary quality, such as noiselessness

Table No. 6.

Type of pavement	Compar. val. wearing sur.	Where used as a general Rule	Average cost per sq. yd.	Est. life	Average annual cost repairs	Int. cost at 5%	Deprec. for sinking fund	Total annual cost per sq. yd. on ec'n.ratio	Per cent.
"Ideal"	100	"Not here"	"0"	"0"	"0"	"0"	----	"0"	
Gran. block	71	Heavy traf.	3.90	30	.02	.19	.07	.28	100
Creo. Wd. blk	80	Bus. sts.	3.00	15—20	.02	.15	.13—.08	.30—.25	105—88
Brick	75	Alleys and car line sts.	2.10	20	.03	.10	.06	.19	67
Sheet asph.	76	Res. sts.	1.70	16	.04	.08	.06	.18	63
Asph. concr.	69	Res. sts. and Blvds.	1.50	12—20	.03	.07	.07	.17	60
Waterbd. mac.	56	Not used since 1911	1.15 (1911)	(4)	(.10)	.06	(.15)	(.31)?	108
Tar or asph. mac.	64	Light traf. sts.	1.20	8	.08	.06	.12	.26	90
Plain concrete	70	Alleys and lt. traf. sts.	1.50—1.80	6—10	.07	.08	.10	.24 av.	85

and healthfulness. These values will vary depending on circumstances, and are interesting in a comparative way only.

Column 5 gives the average or "expected" life of the wearing surfaces. Column 9 gives the annual cost per sq. yd. to provide for maintaining the road through proper and timely repairs, interest on the first cost and amount to be set aside, which compounded at 5 per cent would pay for rebuilding both foundation and top as they wore out. Column 10 shows the relative annual costs in percentage, with granite block assumed at 100 per cent.

An inspection of table No. 6 reveals many interesting things. Considering the traffic it is subjected to, granite block pavement is the most "economic." Were macadam used where the granite block is necessarily specified, it would probably cost four times as much as the granite block. A macadam pavement is not a "cheap" pavement, because of the low wearing value of the surface and the low salvage value of the base or foundation. Three pavements (brick, asphalt and asphaltic concrete) cost about the same. The selection of the proper one for a given street then will depend on other qualities, such as noiselessness, sanitation, good footholds, ease of maintenance, general acceptibility, and local conditions.

Conclusion.

The engineer often has too little experience to decide as to the more desirable type of pavement, as well as to the elements of its construction. In this case he should be advised by competent specialists. Often, though able, he is not consulted, and the public, with its opinion crystallized by the happy assurances of the elusive promoter, adopts a kind of pavement not suitable to the conditions.

The present Illinois assessment law permits the people to select the kind of improvement they desire at a public hearing, regardless of the interests of the general public or the science of economic engineering. It is certainly our duty as engineers to correlate our facts based on definite experiment, observations and tests. and place pavement design and construction on a scientific plane. When we have done this, and have explained to the general public the reasons and wisdom of rational design and stable construction, then are we justly entitled to be the final judges of the character of an improvement. A competent

engineer's advice as to the kind and thickness of a foundation is often unheeded, with the result that the pavement fails, which is no fault of the wearing surface, nor of the ability or honesty of the contractor, inspector or engineer.

It is often necessary to vary the kinds and types of pavement to suit various conditions on the single job. Standards and uniformity, while easy to specify, must be modified to suit definite conditions. A specification, which is successful in one locality, may be a failure in another; due to climate, traffic, grades, poor subgrade, and inadequate experience and equipment of the inspector and contractor.

An engineer, in recommending an improvement, should give the reasons for the type of design adopted and for the kind of construction deemed best for the stated conditions. When the authorities welcome, or rather demand, this of us, then we can furnish, or secure, competent counsel which will in time be appreciated by the public. As the public reposes more confidence in the engineer, which the engineer in turn will merit by rational study, popularly explained, it will be possible to build pavements in a fair, intelligent and economic way. Then the present alleged safeguards usually present in the typical specification, such as contractors' guarantee, irresponsibility of the specifications to secure the desired product, uncertainty of quantities and ignored contingencies, will disappear. Where the contractor must shoulder all these omissions or commissions of the so-called "standard specifications," let it be known that the public pays dearly for their relief of responsibility.

Since the engineer is the agent of the public he should be given the power to specify the best suitable construction and be afforded the support and means of securing it. The specification should be definite and if the contractor executes his work in strict accordance with the specifications he should be relieved of any responsibility or guarantee. Since the contractor is not consulted in the drawing up of the specification he cannot logically be held to account for their insufficiency. The engineer's position and duty is a peculiar one—he must protect the public by requiring good work, and must aid the contractor in securing it. To this end he should know definitely what he is doing, and how it should be done, although he has no right, under conditions where the contractor guarantees the work, to insist on his method

being followed. The engineer's responsibility is vague under prevailing conditions, which places him continually in an awkward position, exposed to criticism from both parties—the unthinking public and the unsympathetic contractor.

[NOTE—Further discussion of this paper is invited, to be received by Joseph W. Peters, 3817 Olive Street, St. Louis, for publication in a subsequent number of the JOURNAL.]

THE PROPOSED MISSOURI-MERAMEC RIVER HYDRO-ELECTRIC POWER DEVELOPMENT

By J. A. Ockerson, M. L. Holman, Edward Flad, E. L. Ohle and H. H. Humphrey, a Special Committee of the Associated Engineering Societies of St. Louis.

[Read and adopted at a meeting of the Associated Societies on June 16. 1915.]

The Senate Committee on Conservation of Water Power, in its report to the Forty-Eighth General Assembly of Missouri, makes the following statement on page 10 of said Report:

"In calling attention to the water power possibilities near the great City of St. Louis, we refer to a project that has been called to the attention of the public in the last few years, and that is diverting a portion of the water of the Missouri River through a canal and emptying it into the Meramec River. This canal would be nine miles in length and do comparatively little injury to property by inundation or otherwise. Outside of our personal investigation, we take our data from that furnished us from a United States Government survey. This location is probably the most important water power in the state, and if figures furnished us, which we have gone over with much care, are correct, this plant would develop 200,000 horse-power, at an estimated cost of construction of ten million dollars. This plant would have an earning capacity, at a very low rate for current, that is so surprising in the final deduction as to create wonder in our minds that with a city like St. Louis so near, with its great manufacturing interests, and a market that could consume all of the output of this plant, that it has not met with successful promotion and completion already.

"We believe that the state should make some effort to see that this power is developed, and in doing so, that such a permit or franchise should be granted as would allow the state to take this property over at the end of a period of years in the event it should be developed by private capital. In fact, it should be built, owned and operated by the state, but by reason of the prohibitions of our constitution this might not be practicable until the general public is educated to a point where they would authorize the development of this and other properties in the state."

The matter was referred to your Committee, which submits the following statement of physical facts connected with the problem of water-power development by diverting Missouri River water to the Meramec River through a properly located canal or tail race. This project has been brought up many times for years past and has been as often rejected as impracticable. The chief source of "wonder" in the minds of Engineers is the persistency with which it is revived as a project worthy of consideration.

The problem involves the difference of level between the Missouri and the Meramec, which necessarily varies with the variations of stage in the two streams.

The question of the construction of a dam across the Missouri for the purpose of increasing the difference of level of the two streams needs little, if any, consideration, since the National Government which has embarked on a twenty-million-dollar improvement project of the Missouri River would hardly permit such obstruction, and the expensive flowage rights would make the cost prohibitive, to say nothing of the difficulty of securing a practicable site for a dam. Since much of the country between the two streams is about 300 feet higher than the tail race, it follows that the connecting channel for a large portion of the distance must be an open cut about 300 feet deep, or a tunnel.

Assuming for a starting point on the Missouri River, the sharp bend in the vicinity of Becker, Mo., we derive the following data from the U. S. Government records of stages: Extreme low water, 441 feet above mean sea level; high water, (being the highest recorded stage except that of 1844) is 482 feet above same datum. During the five years, 1910 to 1914, inclusive, there was a stage of 10 feet (447 feet) or over, for an average of 271 days per year; 15 feet (452 feet) or over, for an average of 93 days per year; and 20 feet (457 feet) or over, for an average of 17 days per year, but only a total of 85 days for the entire period of five years, and one entire year, the stage did not reach 20 feet at all.

Since the stage of 15 feet or more covers only about one-fourth of the time, it is apparent that for one-half of the time the stage would be about 12 feet, or 449 feet above the datum. Under the conditions involved in this discussion, available power for less than fifty per cent of the time is hardly worthy of consideration.

The discharge of the Missouri River at extreme low water is about 20,000 second feet; at a 10-foot stage, 50,000 s. f.; 15-foot stage, 105,000 s. f.; and 20-foot stage, 200,000 s. f.

Between the Missouri River at Becker and the Meramec at Pacific, the distance is about 6¼ miles, and is the shortest distance between the two streams.

The elevation of the bed of the Meramec at Pacific is about 435 feet above mean sea level, which is 6 feet below the surface of the low water in the Missouri River. Take into account the necessary slope in the tail race and the stage of water in the Meramec and the hope of power from the Missouri at low stage vanishes. Furthermore, the entire low-water flow is necessary for purposes of navigation.

Even at the 12-foot stage (449 feet), which is manifestly the economic level to work from, the extreme difference of level between the water surface in the Missouri and the bed of the Meramec is only 14 feet. And after deducting the loss of head in the canal there would remain an available head of about 6 feet. The water surface in the Meramec at flood stage is 2.7 feet (451.7 feet) higher than the 12-foot stage in the Missouri River and the resulting head is negative.

Now leave the head works at the same point on the Missouri and swing the line down to Glencoe on the Meramec, 17½ miles below Pacific, thus taking advantage of the fall in that stream. The length of the tail race is now 9½ miles. To go further down the Meramec would introduce additional complications due to backwater from flood stages in the Mississippi River, which at the mouth of the Meramec reach 40 feet above low water, or 399 feet above mean sea level.

The oscillation in stage of the Meramec between high and low water is 28.6 feet at Glencoe. The slope of the Meramec at high water between Pacific and Glencoe as deduced from the Frisco Railway levels is 16.5 feet, giving a flood elevation at Glencoe of 435.2 feet. With the Meramec at flood stage (435 feet) and low water (441 feet) in the Missouri, there would be a total available head of 6 feet; and with a 12-foot stage (449 feet) in the Missouri, the total available head would be 14 feet. With a 12-foot stage in the Missouri and a bank full stage in the Meramec, the available head would be about 18 feet, and at average low water about 35 feet.

It will readily be seen that the many variables, such as constant changes in relative stages, back water effects from floods in the Mississippi, effect of tail race discharge on the stage of the Meramec, and other unstable conditions which enter into the problem make a general solution covering all of these conditions impracticable. In order to arrive at a result under most favorable conditions we have assumed a 12-foot stage in the Missouri, an average low water stage in the Meramec, and a permissible abstraction of 20,000 second feet, which is equal to the entire low water flow of the Missouri, and about one-fourth of the discharge at a 12-foot stage.

Assuming the tunnel to have a section 30′x100′ and assuming the flow to be 20,000 cubic feet per second, the velocity would be 6.7′ per second. The required slope of the tunnel, or the loss of head due to friction would be 1.3′ per mile, or a total of approximately 13′ for the 9½ miles of tunnel. Assuming a total available head of 35,′ there would be 22′ of head available for power. This would give 50,000 water horse-power with a flow of 20,000 cubic feet per second. With an efficiency of 75 per cent in turbines and generators, there would be available 37,000 effective horse-power.

It will be readily seen, therefore, that under most favorable circumstances the useful energy that can be developed will be only one-sixth of the amount given in the report of the Senate Committee, and this for an average of only one-half of the time.

It is also believed that the cost of a canal or tunnel, connecting the Missouri and the Meramec, of the dimensions required to carry such a large volume of water, and the installation of the necessary plant, would far exceed,—perhaps double,—the estimate stated in the report of the Senate Committee.

In arriving at these results, most favorable conditions have been assumed throughout, and the effective power deduced is materially greater than could be hoped for under normal conditions. The volume of water diverted from the Missouri River would necessarily be subject to Government regulation, and it does not seem probable that it would exceed 20,000 second feet, and more likely would be less.

In view of the results deduced by our investigations it is the opinion of your Committee that the proposed hydro-electric de-

velopment by means of diversion of the waters of the Missouri River into the Meramec is impracticable and not justified by the possible results.

The Committee is indebted to the Engineers of the Frisco and Missouri Pacific Railways for water surface elevations in the Meramec.

[NOTE.—Further discussion of this paper is invited, to be received by Joseph W. Peters, 3817 Olive Street, St. Louis, for publication in a subsequent number of the JOURNAL.]

ASSOCIATION OF ENGINEERING SOCIETIES

ORGANIZED 1881.

Vol. 55. SEPTEMBER, 1915. No 2

THE MISSISSIPPI RIVER

By J. W. WOERMANN,*
MEMBER OF THE ENGINEERS' CLUB OF ST. LOUIS.

Written for the New International Encyclopedia and printed in the Journal by permission of Dodd, Mead & Company.

Table of Contents.

MISSISSIPPI RIVER (Algonquin, Missi Sepe, great river; literally, father of waters). The principal river of the North American continent, discovered by De Soto in 1541. In 1673, Marquette and Joilet descended it almost to its mouth, and in 1682 La Salle passed through it to the Gulf of Mexico and took possession of the country in the name of the King of

*Assistant Engineer, Western Division, U. S. A.

France. Counting as a part of it the longest branch of the drainage system, the Missouri, which far overtops the central stem, it is the longest river in the world. The entire system lies within the United States excepting the headwaters of a few tributaries of the upper Missouri, which extend a short distance beyond the northern boundary of Montana into Canada. It receives the drainage in whole or in part of twenty-seven states. Its soil resources, on account of the semi-arid territory west of the Mississippi Basin, exceeds three-fifths of the total resources of the United States. It has been characterized as the greatest single estate laid out for the habitation of man.

Location and Climate.

Popularly, the name Mississippi is applied to the main north and south stem, which rises in northern Minnesota and empties into the Gulf of Mexico. Its headwaters are in latitude 47° 09′ N., longitude 95° 13′ W., and its central mouth in latitude 28° 59′ N., and longtitude 89° 08′ W. Although well within the Temperate Zone there is a wide range of climate, particularly in winter temperatures. In northern Minnesota the extreme range in temperature is from —50° F., to +100° F., while at New Orleans it varies from +20° F., to +100° F. These temperatures do not occur every year, but are likely to occur three years out of ten. The mean annual temperature at Duluth is 39° F.; at New Orleans, 69° F. The chief agricultural products in the north are wheat, barley and potatoes, in the central states, corn, oats and rye, and in the south, cotton, sugar cane and tobacco. Fruits are grown throughout the valley, apples better in the north and peaches more successfully in the south.

The Mississippi forms the east or west boundary line, in whole or in part, of ten states: Minnesota, Wisconsin, Iowa, Illinois, Missouri, Kentucky, Tennessee, Arkansas, Mississippi and Louisiana. The principal cities situated on its banks are Minneapolis, St. Paul, La Crosse, Dubuque, Moline, Davenport, Rock Island, Burlington, Quincy, St. Louis, East St. Louis, Cairo, Memphis, Vicksburg, Natchez, Baton Rouge and New Orleans.

Source.

Popularly, Lake Itaska, since its discovery by Schoolcraft in 1832, has been considered the source of the Mississippi and this is not far from being precise. Later explorers announced Nicollet Creek, Elk or Glazier Lake, Gagwa Dosh or Dear Creek, and Hernando de Soto Lake as the headwaters. According to an accurate contour map of Itaska State Park, issued by the Mississippi River Commission about 1910, Little Elk Lake is the "ultimate source." It empties into Lake Itaska through Elk (or Excelsior) Creek and Elk Lake. Lake Itaska is surrounded by such an intricate network of smaller glacial lakes, more or less obscured by reeds and water grass, that it is easy to understand why this question was a matter of so much controversy until the whole Itaska Basin was covered by a careful geodetic survey. Lake Itaska at its outlet is 2,459 miles from the Gulf of Mexico, and Little Elk Lake about 7 miles farther. Lake Itaska is about 4 miles long, 30 feet deep, and about 1,470 feet above sea level. Little Elk Lake is about half a mile long, 600 feet wide and about 100 feet higher than Lake Itaska.

General Description.

The Mississippi as it flows from the north end of Lake Itaska is ordinarily less than 20 feet wide and 2 feet deep. It flows swiftly over shoals and boulders in a northwesterly direction for a distance of 62 miles by river, or 32 along the axis of the valley, to Lac Travers, or Lake Bemidji, covering about 20 square miles, surrounded by forested hills. The Mississippi as it flows from the east side of Lake Bemidji is at the most northern point of its course. Seventeen miles farther on it enters Cass Lake, which is twice as large as Bemidji, and twelve miles beyond Cass Lake it enters Lake Winnibigoshish, which is twice as large as Cass Lake. From Lake Winnibigoshish, the river flows southeastwardly for 24 miles and unites with Leech Lake River, which is nearly as large as the Mississippi, and furnishes the outlet for Leech Lake, which covers about 250 square miles, and is the largest of the lakes constituting the headwaters of the Mississippi. Forty miles farther, or 180 miles from Lake Itaska, is found the first rock in place, a bed of sandstone, where the Falls of Poke-

gama have been submerged by two dams. Eighty miles below Pokegama the waters of Sandy Lake empty into the Mississippi through a storage dam, and 82 miles below Sandy Lake enters Pine River, which is dammed a short distance above its mouth to regulate the outflow from Whitefish Lake. Twenty-two miles below Pine River is located the town of Brainerd with a population of 10,000 and a water power dam with a 15-foot head. Between Brainerd and Minneapolis, occurs a series of dams and rapids having a total fall, with the Brainerd Dam, of 444 feet, as stated in the section on slopes and water power. The Crow Wing River, which is nearly as large as the Mississippi, enters 11 miles below Brainerd. At the Sauk Rapids, 60 miles below the Crow Wing, and at the entrance of Sauk River, begin the first rocky banks of Potsdam sandstone, which are in frequent evidence from this point down to the head of the Rock Island Rapids, 350 miles below St. Paul.

The entire drainage basin of the Mississippi above Minneapolis is covered with a blanket of glacial drift, 100 to 300 feet thick, consisting of a mixture of clay and gravel. Its surface is very irregular and is broken by thousands of glacial "pot holes," resulting in a vast multitude of lakes and swamps, estimated by some at 5,000 to 6,000 in number. At the Falls of St. Anthony in Minneapolis, the river pitches down a vertical falls and rapids amounting to 80 feet in half a mile, leaving the clay banks for a channel that lies between vertical bluffs of sandstone, gradually increasing to a height of 300 to 500 feet as the bed sinks below the general level of the prairie. Below St. Paul the distance between the bluffs rapidly increases, so that from St. Paul to Rock Island the usual distance between bluffs is 2 to 3 miles, except at the head of the Rock Island Rapids, where they are only one mile apart. Their height varies from 200 to 600 feet. The debris from centuries of degradation has built up slopes at the foot of the bluffs and on all projecting ledges which are now covered with grass and trees. For more than 200 miles below St. Paul the oaks, elms, beeches and maples are interspersed with cedars and pines. This fact, together with the greater height of the bluffs, makes this section even more beautiful than the bluffs farther south. The river flows first against one bluff and then the other in its meanderings back and forth across the valley.

Seventy-seven miles below St. Paul the vast quantities of sand brought down by the Chippewa River have choked the valley so that the river fills the entire space from bluff to bluff, forming Lake Pepin, which is approximately 25 miles long and 2 to 3 miles wide. At the Rock Island Rapids the bed of the river consists of stratified limestone in a series of folds or steps, creating 11 "chains" or rapids with a total fall of 21 feet in 15 miles. From this point down to Cape Girardeau, 132 miles below St. Louis and 460 miles from Rock Island, the formation is carboniferous and the river winds back and forth between picturesque rocky bluffs 100 to 400 feet high and from 3 to 8 miles apart. The bluffs are usually partially covered with grass and trees, as above Rock Island; but from Grafton to Alton, a distance of 18 miles, and for shorter distances below St. Louis, the bluffs rise vertically from the river, forming palisades of rugged beauty. From Cape Girardeau down to Gray's Point, a distance of 5 miles, the river passes the low land which constitutes the head of the St. Francis Basin, through which the flood waters of the Mississippi formerly escaped in great volumes. From Gray's Point to Commerce, a distance of 7 miles, the river flows through a "gorge" where the water is closely confined between vertical bluffs one-half to three-quarters of a mile apart. This geological landmark is said to be a spur of the Ozark Mountains which cross the southern part of Missouri.

The rock bluffs between which the river meanders for more than a thousand miles and the vast northern upland, mainly elevated rock with a moderate covering of soil, both terminate at Commerce, 144 miles below St. Louis and 38 miles above the mouth of the Ohio. The vast alluvial valley of great fertility extending from Commerce to the Gulf, about 1,100 miles by river, or 600 miles in a direct line, has been created from the river's own silt. Commerce is at the head of an ancient arm of the ocean into which the silt-laden river poured its deposits as the present river does into the Gulf, leaving a valley as fertile as that of the Nile in its palmiest days and four times as large.

From Cairo to the Gulf the surface of the river is normally above the lands lying back from the river. In other words, the river runs in a groove cut into a ridge considerably above the surrounding country. The ground slopes away from the river

with a gradient of about 7 feet in the first mile, decreasing gradually to 6 inches per mile at the outer edge, where the overflow from the Mississippi naturally drained away toward the Gulf through numerous bayous running parallel to the main river.

Between Cairo and Memphis, 230 miles, the river does not get far from the low bluffs on the east side of the valley and at several points impinges upon them. The river then zigzags diagonally across the wide valley and strikes the west bluff at Helena, 306 miles below Cairo. The St. Francis Basin, which is 45 miles wide just below Cairo and 35 miles wide at Memphis, tapers out at Helena, where the St. Francis empties into the Mississippi. The Yazoo Basin, which starts at Memphis on the east side of the river, increases in width as the St. Francis decreases, having a width of 22 miles at Helena, and 60 miles opposite the mouth of the Arkansas River, which is 402 miles below Cairo. At Arkansas City, 438 miles below Cairo, the Yazoo Basin reaches its maximum width, 65 miles, and the Tensas Basin begins on the west bank. The Yazoo Basin terminates in a wedge at Vicksburg, 600 miles below Cairo, where the Yazoo enters the Mississippi, and the latter again strikes the east bluffs, which at this point are about 200 feet high. The Tensas Basin, which is from 20 to 35 miles in width, terminates at the mouth of the Red, of which the Tensas is a tributary. There is no diminution in the width of the basin, however, only a change in the name, which from this point to the Gulf is known as the Atchafalaya Basin, after the Atchafalaya River, which not only carries the discharge of the Red River, but also at flood times an immense volume from the Mississippi. A narrower basin on the New Orleans side is known as the Pontchartrain Basin. The areas of these several basins are as follows:

St. Francis	6,706	square miles
Yazoo	6,648	" "
White River	956	" "
Tensas	5,370	" "
Atchafalaya	8,109	" "
Pontchartrain	2,001	" "
Total	29,790	" "

Islands, Lakes and Tributaries.

One of the interesting and picturesque features of the Mississippi is its large number of islands. Between St. Paul and the mouth of the Missouri, 658 miles, there are about 540 islands of sufficient size to be dignified with a name or number. They occur singly, in pairs, and in chains,—the lower ones covered with willows, and the higher ones with cottonwoods, maples, and oaks, or else cleared for cultivation. Between the mouth of the Missouri and the Ohio, there are, or were, about 60 islands large enough to be designated by name. Most of them are from 2 to 3 miles long. Nearly all of these 600 islands have been connected with the main land by wing dams or hurdles and the channels or chutes behind them have become silted up so that they no longer appear as islands during low water. This is particularly true below St. Louis, where most of the islands have already lost their identity except to those familiar with the river. Between Cairo and the mouth of the Red River, a distance of 765 miles, there are 147 islands, usually 2 to 4 miles in length. From this point to the Gulf, 309 miles, there are only 3 islands and except at these points the river sweeps along majestically in a single deep channel.

An equally interesting feature is the great number of large horseshoe lakes which lie adjacent to the river, particularly from Memphis to the mouth of Red River, where in a distance of 534 miles there are 31 of these crescent-shaped lakes, most of them from 5 to 10 miles long. These are former channels of the river which were abandoned as the result of "cut offs," described in a later paragraph. The number of tributaries, and tributaries of tributaries, which are shown in ordinary atlases, number about 250, of which more than 50 are navigable. The more important of the tributaries in the order of their entry proceeding downstream from Minneapolis, are the Minnesota, St. Croix, Chippewa, Black, Wisconsin, Galena, Rock, Iowa, Des Moines, Salt, Illinois, Missouri, Kaskaskia, Ohio, St. Francis, Arkansas, Yazoo, Big Black and Red.

Watershed.

The area drained by the Mississippi River and its tributaries extends from the Allegheny Mountains to the Rocky Mountains and from the St. Lawrence Basin to the Gulf of Mexico,—

1,240,050 square miles, or 41 per cent of the main land of the United States, exclusive of Alaska. The areas of the principal river basins which form this immense watershed are as follows:

Designation.	Area sq. miles	Percentage of whole.
Missouri	527,150	43
Upper Mississippi	165,900	13
Ohio	201,700	16
Middle and Lower Mississippi	69,000	6
Arkansas	186,300	15
Red	90,000	7
Total	1,240,050	100

Divisions and Length.

For purposes of investigation and improvement the Mississippi River is divided by the Government Engineers as follows:

District.	Length, Miles
Little Elk Lake to St. Paul	534
St. Paul to mouth of Missouri River (Upper Mississippi)	658
Mouth of Missouri River to mouth of Ohio River (Middle Mississippi)	200
Mouth of Ohio River to Head of Passes (Lower Mississippi)	1060
South Pass	14
Total	2466

These distances are measured along a line midway between the banks. Distances measured along the steamboat channel are more than 10 per cent greater.

In volume of sediment and other characteristics the Missouri River is the main stream and should have been named the Mississippi. Measuring from the headwaters of the Missouri River to the Gulf, it has a total length of 4,200 miles,—the longest river in the world.

Reservoirs and Capacities.

Near the headwaters of the Mississippi, a series of lakes have been dammed by the government in order to create a system of storage reservoirs for increasing the low water flow and depth of navigable channel of the upper river. The capacities of these reservoirs are given in the following table; together they constitute the largest reservoir system in the world.

Name of Reservoir.	Area at Low Water sq. m.	Area at High Water sq. m.	Range in Ht. ft.	Storage Capacity. cu. ft.
Lake Winnibigoshish and Cass Lake	117	161	14.0	43,992,000,000
Leech Lake	173	234	5.7	33,094,300,000
Pokegama Lake	24	25	7.5	5,260,000,000
Sandy Lake	8	16	9.4	3,157,900,000
Pine River	18	24	16.2	7,732,900,000
Gull Lake	28	30	6.0	4,910,100,000

Widths, Natural and Artificial.

From Lake Itaska to Minneapolis, the width of the river increases gradually from less than 50 to more than 400 feet at ordinary stages. Under the adopted project for the deepening of the river the low water width is contracted to 300 feet at St. Paul. As the volume of flow is increased by the various tributaries this width is increased by degrees to 600, 700, 900, 1,000, 1,200 and 1,400 feet, the latter width being for the reach between the mouths of the Illinois and Missouri. On the Rock Island Rapids the width between contraction works is 250 to 400 feet. Where the Des Moines Rapids formerly existed there is now a beautiful artificial lake about a mile wide and 50 to 60 miles long, created by the new concrete power dam at Keokuk. The natural width from St. Paul to the mouth of the Missouri is from two to three times these project widths, except in Lake Pepin, where the natural width of two miles has not been disturbed.

From the mouth of the Missouri to the mouth of the Ohio, the project width is 2,500 feet, although the widths in the unimproved sections vary from 800 to 5,000 feet. The widths in this reach at a bank full stage vary from 1,600 to 7,000 feet. The flood width, before the construction of levees, extended from bluff to bluff, an average distance of five miles.

Below Cairo the project width is 3,000 feet, the natural low water width 1,000 to 7,500 feet, and the bank full width, 2,000 to 10,500 feet. Previous to the construction of levees the area subject to overflow had an average width of 40 miles. At the present time the average restricted flood width is 5 to 10 miles, decreasing to about 1 mile below Baton Rouge.

Slopes, Water Power, Locks and Dams.

From Lake Itaska, which is 1,472 feet above sea level, to Bemidji, there is a fall of 130 feet in 32 miles. At Bemidji there is a power dam with a head of 22 feet. From this point to Brainerd, a distance of 300 miles, the river flows through a country which is largely swampy, but the flat slopes of the river are interrupted by the storage dams at Lake Winnibigoshish and Pokegama Lake, by a power dam at Grand Rapids and by several smaller rapids farther downstream. The crest of the Brainerd power dam is 1,172 feet above sea level. From this point to Minneapolis, a distance of 150 miles, there is a fall of 444 feet, 80 of which is in the falls and rapids of St. Anthony. About 135 feet of this 444 is utilized by six power dams; the remainder is wasted.

Between Minneapolis and St. Paul the United States Government is just completing a large lock and power dam, with a lift of 30 feet, which will permit the packets from St. Louis to reach Minneapolis. From this point to Le Claire, at the head of the Rock Island Rapids, the average slope is about 0.4 foot per mile, except in Lake Pepin, where the river has a fall of less than 0.2 foot in 24 miles. At the Rock Island Rapids there is a fall of 21 feet in 15 miles. From this point to the head of Cooper Lake at Burlington, a distance of 84 miles, there is an average slope of 0.35 foot per mile.

Cooper Lake, named after the Civil Engineer who designed and built the hydro-electric power plant at Keokuk, is 50 to 60 miles long and nearly level. The head on the dam and the lift in the new government lock will vary from 30 to 40 feet, according to the amount of water stored in the pool. From Keokuk to Grafton, at the mouth of the Illinois River, a distance of 150 miles, there is a slope of 0.5 foot per mile; from Grafton to the Eads Bridge at St. Louis, 0.66 per mile, although the maximum at the Chain of Rocks above St. Louis, is 1.3, and the minimum, in the St. Louis harbor, 0.2 per mile. Low water at this point is about 378 feet above Gulf level.

From the Eads Bridge to Cairo the average slope is 0.6 foot per mile; from Cairo to Vicksburg, 600 miles by river, 0.38 per mile; from Vicksburg to the mouth of Red River, 154 miles, 0.24 per mile. This point is over 300 miles from the Gulf and only 3 feet above Gulf level. Practically all of this head is used up in

the next 70 miles, so that at Baton Rouge, 240 miles from the Gulf, low water is only 0.2 foot above mean Gulf level. Although the tides at the mouth of the river amount to only one to two feet, their effect extends up the river to Baton Rouge, and below this point there is a slight negative slope during high tide. In other words, contrary to popular opinion, water does run up hill under certain conditions.

Depths, Prior and Subsequent to Improvement.

Between St. Paul and St. Louis, prior to improvement, the depths on the bars or crossings at low water did not exceed 2.0 to 2.5 feet, especially in the upper sections and on the Rock Island and Des Moines Rapids. About two-thirds of this division has now been improved to a low water depth of 6.0 feet. Where the improvements have not been completed depths of not less than 4.0 feet are maintained by dredging. From St. Louis to Cairo the minimum depths, previous to improvement, did not exceed 3.5 to 4.0 feet at low water. At present, by means of improvement works and dredging, a depth of 8.0 feet is maintained. From Cairo to the Gulf the minimum depths, prior to improvement, did not exceed 4.5 to 6.0 feet at low water. At the present time, by means of improvement works and dredging, primarily the latter, a minimum depth of 9.0 feet is maintained from Cairo to Vicksburg. Below Vicksburg no dredging is required, the least depths being 11.0 feet from Vicksburg to Baton Rouge, 35 feet from Baton Rouge to New Orleans, 62 feet from New Orleans to Quarantine Station, and 30 feet to the Gulf through either the South Pass or the Southwest Pass.

Velocity of Current.

The velocity of the current is a function of the depth as well as of the slope, that is, it varies according to the square root of each. The velocity of the current varies greatly, therefore, between low and high water at every point on the river. The velocity at low water, however, does not differ greatly on the upper and lower river, as the greater depths on the lower river are largely counterbalanced by the flatter slopes. Roughly speaking, the velocity at low water, from St. Paul to St. Louis, except on the rapids, varies from 1.0 to 2.0 feet per second, and from St. Louis to New Orleans from 1.0 to 2.5 feet, while the high water

velocities vary from 3.0 to 6.0 feet on the upper river and from 6.0 to 8.0 feet on the lower river. The greatest velocity that has been noted on the river occurred under the Merchants' Bridge at St. Louis during the flood of 1892, when a mean velocity of 12.2 feet per second was measured. The excessive contraction of the waterway under the bridge caused the bottom to scour out to a depth of 86 feet on this occasion. (To obtain the velocities in miles per hour, multiply the preceding figures by 0.7.)

Rainfall and Run-off.

The mountain ranges which bound the Mississippi Valley on the east and west exert a very important influence on the rainfall and floods in the valley. The winds which carry moisture westward from the Atlantic Ocean, precipitate most of it on the east side of the Appalachian Mountains, while those from the Pacific Ocean are similarly intercepted by the Rocky Mountains, so that the Mississippi Valley receives very little rain from either source. A small percentage of rain comes from the Great Lakes, but the heavy rains which produce great floods come from the Gulf of Mexico. In the winter and spring, the surface of the ground is cooler than the waters of the Gulf and as the moisture-laden winds sweep northward they become cooled and create snow and rain. A wind from the southwest will sweep across the Ohio Valley; from the south, up the Mississippi; one from the southeast across the valleys of the Red, the Arkansas and the Missouri; but in all cases the greatest rainfall will occur near the Gulf and gradually decrease as the winds travel inland. Thus the average annual rainfall at New Orleans is 60 inches, at Memphis 52 inches, at Cincinnati 42 inches, at Pittsburgh 36 inches, at St. Louis 40 inches, at Brainerd, Minn., 25 inches, and at the headwaters of the Missouri only 13 inches. Floods do not arise from mean conditions, but from heavy rainfalls of long duration; if the ground is frozen or saturated the run-off is proportionately greater. At any rate, the figures just given indicate in a general way the run-off which may be expected from the different sections of the valley and they also show the futility of attempting to control floods in the main valley by forests and reservoirs at the various headwaters.

Volume of Discharge.

The ordinary or normal low water discharge and the maximum flood discharge of the river at typical points are shown in the following table. By ordinary or normal low water is meant the lowest stage which occurs during the navigation season. Occasionally, in mid-winter, when the tributaries above St. Louis are all frozen over, the discharge at and above St. Louis may be 25 per cent less than is shown in the table. Since the opening of the Chicago Drainage Canal in January, 1900, about 5,000 cubic feet per second have been taken from Lake Michigan through the Chicago River, the Chicago Drainage Canal, the Des Plaines and Illinois Rivers, and discharged into the Mississippi at Grafton. At and below Grafton, therefore, the present low water discharge is 5,000 cubic feet per second greater than the natural discharge shown in the table.

These extreme low water discharges do not occur every summer, but only once in five to ten years. The low water discharge shown for St. Louis corresponds to a zero stage on the St. Louis gauge, while "standard low water," which is approximately the average annual low water during the navigation season, corresponds to a discharge of 63,000 cubic feet per second.

NATURAL DISCHARGE OF THE MISSISSIPPI RIVER.

Name of Station.	Distance From Gulf. Miles.	Ordinary Low Water Discharge cu. ft. per sec.	Maximum Flood Discharge cu. ft. per sec.
Above Cass Lake	2,370	100	2,000
Grand Rapids, Minn.	2,278	500	10,000
Brainerd, Minn.	2,107	1,500	40,000
St. Paul, Minn.	1,934	3,000	110,000
Winona, Minn.	1,814	6,000	130,000
Clayton, Iowa	1,711	12,000	200,000
Keokuk, Iowa	1,447	18.000	372,000
Grafton, Ill.	1,295	20,000	425,000
St. Louis, Mo.	1,257	35,000	1,146,000
Columbus, Ky.	1,052	70,000	2,015,000
Helena, Ark.	768	77,000	2,041,000
Arkansas City, Ark.	636	92,000	2,007,000
Vicksburg, Miss.	475	97.000	1,783,000
Red River Landing, La.	309	94,000	1,595,000
New Orleans, La.	110	94,000	1,358,000
Mississippi & Atchafalaya & Crevasses.	0	100,000	2,300,000

The differences between successive values in the above table indicate in a general way the contributions from the principal

tributaries. For example, just above St. Paul enters the Minnesota River with a drainage area nearly as large as that of the Mississippi above their junction. The differences between the discharges at Grafton and St. Louis represent the values for the Missouri River, showing that the low water discharge of the Missouri is smaller but its flood discharge considerably larger than that of the Mississippi at that point. The same statement is true of the Ohio River.

Just above Red River Landing is the mouth of the Red River, which also serves as the mouth, or rather as the headwaters, of the Atchafalaya River, because ordinarily the latter takes all of the discharge from the Red River and also some from the Mississippi River, as indicated in the table. The reduction in flood discharge below Helena is due to the escape of water through the crevasses or breaks in the levees, as described further on under Levees.

Disastrous Floods.

The maximum discharge of the upper Mississippi is 450,000 cubic feet per second; the Missouri on account of its great length, 900,000; the Ohio, 1,400,000; the Arkansas, 450,000, and the Red, 220,000. There is also a large discharge from the St. Francis, Yazoo, White and Tensas. Below Cairo the river overflows its banks when the discharge exceeds 1,000,000 cubic feet per second. The flood of 1912 was the greatest below Cairo of which we have definite knowledge, and amounted to about 2,000,000 cubic feet per second at Cairo and 2,300,000 flowing into the Gulf. This flood was due to the coincidence of moderately high floods from the Missouri, upper Mississippi, Ohio, Wabash, Tennessee and Cumberland Rivers, supplemented by excessive rains covering the alluvial valley and the watersheds of the southern tributaries.

The alluvial valley having been built up by floods, it follows that they must have always occurred. Naturally, only the more disastrous floods are remembered and recorded and the older ones are gradually forgotten as those of more recent date attract the attention. This is partly due to the fact that when the valley was only sparsely settled very little damage was possible, but as it has become more thickly settled the opportunity for disaster has increased a hundred-fold. The floods of 1785, 1828 and 1844 were

of abnormal height and did great damage, and stirred the people in the valley to renewed efforts at levee construction. Then came the great floods of 1851 and 1858. The latter was regarded as the greatest which had ever come down the river and overtopped practically all of the levees in existence at that time. Active repair work and extensions were followed by other great floods in 1862, 1865, and 1867, which supplemented the havoc of the war and did millions of dollars worth of damage. Active reconstruction was followed by the great flood of 1874, which in many parts of the valley proved to be the most disastrous of all. Then in 1882, 1883, and 1884, the valley was visited for the first time by three excessive floods in three successive years. In 1882 there were 284 crevasses; in 1883, 224; in 1884, 204; 712 crevasses in three years! A large part of the lands reverted to the states on account of the inability of the owners to pay the heavy levee taxes, and in 1882 the Federal Government came to the rescue and began its co-operation with state and local organizations as stated in the section on Levees. The greatest activity ever witnessed on the levees followed and the results were most encouraging.

Floods of greater volume than that of 1874 also occurred in 1886, 1887, 1892 and 1893, but, on account of the greatly improved levee system, these were all safely passed without material damage except that due to erosion. But in 1897 came another of unusual severity, causing 47 crevasses and flooding 20,000 square miles. This was followed by even greater activity in levee construction, and after the flood of the following year, the Mississippi River Commission reported: "This is the first time in the history of the river since the commencement of the continuous levee system that a flood reaching the height of 49.8 feet on the gauge at Cairo has been carried to the Gulf without a single break in the levee." For five years the levees successfully held back the floods, but in 1903 another great flood came and the levees were again breached, doing enormous damage. In 1907 the flood was only a trifle lower than that of 1903 and the damage done was estimated as high as $100,000,000. The next year was remarkable for four moderate floods in succession, beginning in February and ending in June, followed by another in 1909. The latter was about as large as that of 1874, but all were carried through to the Gulf without any break in the levees.

In 1912 came the greatest flood on record, causing 14 crevasses below Cairo and a loss in property estimated at $42,000,000. There was some loss of human life but the number of lives lost was never ascertained. The army officers reported that 272,000 people were furnished food and shelter.

In 1913 two distinct and excessive floods passed Cairo, the first in January and the second in April. The second exceeded in height all previous records for nearly the entire distance from Cairo to the Gulf. Like that of the preceding year it was caused by excessive rains throughout the valley. The precipitation at a number of Weather Bureau stations in Ohio exceeded all previous records for a like period of time. At Cincinnati, the Ohio rose 21 feet in one day. The flood of January was kept within the levees except at Beulah, where a break of the previous year had not yet been completely closed. This crevasse attained a width of 1,000 feet and overflowed about 2,100 square miles. During February and March it was closed successfully at great cost by means of a trestle, using 1,374 cars of rock and 145,000 cubic yards of earth. During the April flood 6 crevasses occurred, overflowing 2,568 square miles, but, in addition, 6,756 square miles were overflowed by water coming through various unleveed sections.

An important contributory cause of repeated failures after so many years of levee building is the fact that as the areas formerly subject to overflow are more and more protected from overflow, the channel left for the flood waters has become more and more restricted and the water surface has steadily risen. The former flood width of 20 to 80 miles has now been reduced to about 5 miles and the flood height increased about 10 feet. This was anticipated and correctly computed twenty years ago, but the funds available have not yet been sufficient to enlarge the levees to the full cross-section required. The waters of the upper Mississippi, Missouri and Ohio having been combined at Cairo, the gauge at that point is an accurate index of the relative volumes of different years, particularly since it is not so much affected by breaks or extensions in the levee system as the gauges farther down. However, two floods passing Cairo at the same stage do not always remain of the same proportion throughout the lower valley as they are affected to some extent by the discharge from the tributaries below Cairo. The maximum reading at Cairo for

every flood from 1858 to 1914, inclusive, is given in the following table:

FLOOD HEIGHTS ON THE CAIRO GAUGE.

Year	Day	Feet
1858	June 21	49.53
1859	May 7	46.49
1862	May 2	50.76
1865	March 19	47.90
1867	March 21	50.97
1874	April 26	47.37
1876	April 6	46.38
1882	February 26	51.87
1883	February 27	52.17
1884	February 22	51.79
1886	April 19	51.02
1887	March 9	48.50
1892	April 28	48.29
1893	May 9	49.33
1897	March 25	51.72
1898	April 6	49.78
1899	April 2	46.24
1903	March 16	50.57
1904	April 5	49.10
1906	April 9	46.90
1907	January 27	50.33
1908	March 19	45.55
1909	March 16	47.27
1912	April 6	53.94
1913	January 28	48.89
1913	April 7	54.69

Extreme low water is—1.0 feet on the gauge.

Caving Banks.

In the volume of its caving banks, the Mississippi probably surpasses every other river that man has yet attempted to improve. In the superficial area of its caving banks it is exceeded by the Missouri, but on account of the higher banks and greater depths of water on the Mississippi the volume of earth falling into the river is greater along the latter. Previous to the revetment or protection of the banks some caving occurred on the upper Mississippi as far north as Keokuk, but caving on a large scale really begins at the mouth of the Missouri River and increases in extent downstream, reaching a maximum in the vicinity of Vicksburg. Below the mouth of Red River the caving gradually diminishes until at Donaldsonville it practically ceases.

From Cairo to Red River the extent of the caving banks was

measured in 1907 and 1908 and it was found that 411 miles of bank were caving at low water and 708 miles at high water, or, deducting for the banks which were caving at both low and high water, a total of 749 miles in 754 miles of river. In other words, caving is taking place on one bank or the other, or on some island, over practically the entire distance. A similar survey in 1892, before much revetment work had been done, showed 921 miles of caving banks in the 885 miles from Cairo to Donaldsonville. The same survey showed that the average annual caving in this distance amounted to 38,991,000 square yards, or 12.6 square miles in area by 66 feet in depth, or more than 1,000,000 cubic yards per mile of river.

Similar measurements between Cairo and St. Louis show that from 1879 to 1889 the average annual amount of caving was 64,000,000 cubic yards, while from 1889 to 1907 the average annual amount was 48,000,000, the diminution being due to the extensive revetment work executed in the meantime.

Caving banks have been classified as eroding banks, slumping banks, sinking banks, and sliding or slipping banks. As most of the damage is done by the first method, no further reference will be made to the others. A typical eroding bank is one whose soil is not cohesive enough to withstand the scouring and dissolving action of the ordinary river currents. As the velocity of the current increases with the stage, the erosion increases correspondingly, provided the direction of the current remains the same. As the direction of the current is frequently different at high water, caving, while much more extensive, does not always occur at the same places. In erosion the bank is undercut or undermined below the water surface until the weight of the portion above the water causes it to break away and fall into the river. A recession in the shore line of 300 to 600 feet in a single season is a common occurrence.

Sinuosities.

Experiments on a large scale show that a running stream in an alluvial bed will not remain straight. Owing to variations in the cohesive strength of the soil, irregularities begin to develop and the resulting curves are gradually enlarged by the centrifugal action of the currents thereby inaugurated. The resulting radius of curvature is determined largely by the volume of discharge, though also affected by the composition of the banks. For ex-

ample, below St. Paul the radius of curvature is 1,600 to 4,500 feet, while in the bends below Arkansas City it is from 8,000 to feet, while in the bends below Arkansas City it is from 8,000 to a flood discharge it attempts to adjust its sinuosities to its increased flow. In other words, at a flood stage the current does not follow the deep bends in which it flowed during low water but tends to flow in flatter curves, thereby shortening and changing the course of the main channel to the confusion of the navigator.

The greatest danger to the regimen of a river occurs, however when the erosion in one bend approaches the cutting bank in the second bend below. If left to itself the peninsula or narrow neck of land will be eventually cut through, thereby forming a "cut off," or sudden shortening of this section of the river. As this disturbs the regimen of the river for many miles above and below, it is always prevented by bank revetment. If not prevented, it may require twenty to twenty-five years before this reach becomes as stable as it was before the cut off took place. The last cut off occurred in 1884, before improvement work was well organized, at Waterproof, 20 miles above Natchez, shortening the river about 12 miles.

Erosion in the bends does not widen the river because the convex bank is built out as rapidly as the other caves away, but it takes many years before the new accretion becomes high enough and fertile enough to be valuable for agricultural purposes.

The Movement of Sediment.

Material is carried down the river in three ways, viz., in solution, in suspension, and by rolling along the bottom. The second is by far the greatest in volume. The material carried in suspension by the Mississippi is received almost entirely from the Missouri River. At low water the proportion of sediment in the Missouri River is about 1 part in 1,000, by weight, while at a flood stage it amounts to 10 parts in 1,000, or 1 per cent of the weight of water. This means that a flood of 500,000 cubic feet per second carries with it into the Mississippi about 120 cubic yards of sediment per second, or more than 10,000,000 cubic yards per day. It is estimated that 400,000,000 cubic yards per annum are carried into the Mississippi from the Missouri, and approximately the same amount passes out into the Gulf. A volume, therefore, equal to that produced by the river's own caving banks is de-

posited as accretions along the banks of the river and on the areas subject to overflow. A deposit or accretion occurs whenever the velocity of the current is checked, as for example, below a hurdle or permeable dike, where the fill frequently amounts to 10 feet during a single flood. One case is on record of a maximum deposit of 64 feet in a single year.

The movement of sand along the river bottom results in the formation of sand waves, a phenomenon similar to the formation and movement of sand dunes or snowdrifts by the wind. Sand waves on the lower river vary from 400 to 1,000 feet in length, from 8 to 22 feet in height and have a daily movement downstream of 20 to 40 feet. They have the least dimensions and slowest rate of travel during low water and the greatest during high water.

Bars and Crossings.

Concurrently with the erosion and accretion in each bend occurs another process which is equally typical of all alluvial streams, viz., the formation of a bar or submerged dam across the channel at the lower end of each bend. These bars do not lie normal to the banks but extend diagonally across the river, having a length at least double the width of the river. In this way the deep water in the upper pool usually extends downstream past the head of the next pool, and the main body of water in passing from one pool into the next passes over this bar or natural weir in a comparatively shallow sheet of water. The deepest water in a bend is always found near the concave bank and the steamer pilot in passing from the deep water in one pool to the deep water in the pool below must make a "crossing" in a diagonal course from one side of the river to the other.

One of the most interesting characteristics of these bars, and a most troublesome one to the navigator, is the fact that the top or crest rises and falls with the water surface. Repeated measurements show that below St. Louis the available depth across a bar increases only about one-half foot for every foot rise in the water surface.

After a high water stage if the river falls slowly, say 0.2 or 0.3 foot per day, the current will have time to cut down the bars fast enough to maintain a good channel, but if the river falls rapidly the result is most disastrous, as there will be "bad water" on the

"crossings" until the current has time to cut them down or the hyrdaulic dredges to dredge a channel through them. For the guidance of the pilots the "crossings" are indicated by lights and day marks maintained by the U. S. Lighthouse Service.

Bank Revetment.

When the permanent improvement or regulation of a river like the Mississippi is undertaken, the first work necessary is the revetment or protection of its caving banks from erosion, giving the channel a fixed location and incidentally conserving the fertile bottom lands along the river and reducing the amount of sediment to be disposed of by the stream. This can be accomplished the most economically by the use of brush and stone revetment, constructed during the low water season. Below the water surface the sloping bank is covered with a "mattress" or carpet of willow brush, covered with a single layer of rubble stone, while above the water level, where the willows would soon rot, stone alone is used in a heavier layer.

The width of the mattress varies with the depth of the river and the friability of the soil. On the upper river the width varies from 25 to 35 feet. between St. Louis and Cairo the standard width is 125 feet, and below Cairo, 250 to 400 feet. On the upper and lower river the mattress is made up of fascines or bundles of willows fastened together with poles and wire cables, while on the middle Mississippi the mattress is made by weaving light willows under and over heavier poles, placed about 5 to 8 feet apart, parallel to the bank. The willows are 20 to 30 feet long and from 2 to 4 inches thick at the butt, except the poles, which are longer and heavier. The mattresses are made on skids supported on barges, the barges being gradually withdrawn downstream, as the mattress is formed, leaving a continuous floating mattress, which is then sunk from the upstream end by loading it with stone.

Above the water level, the bank is first graded by a hydraulic grader to a slope of 1, vertical, to 2.5 or 3.0, horizontal, and covered with rubble stone placed by hand. Where stone must be transported long distances, as on the lower Mississippi, it has been found more economical to use concrete, provided gravel may be found within a reasonable distance. The heights of the banks above "standard low water" varies from 10 to 20 feet on

the upper river, from 20 to 30 feet on the middle Mississippi, and from 40 to 60 feet on the lower river. The total width of the protected slope from the top of the bank to the bed of the river varies from 50 to 500 feet. The cost of bank revetment on the upper river is from $5.00 to $7.00 per lineal foot of bank, on the middle Mississippi from $12.00 to $18.00, and on the lower river from $30.00 to $40.00.

Contraction Works.

Contraction works, as indicated by the name, are built for the purpose of contracting the cross-section of the river where its natural width, at low water, is too great and its depth too shallow to afford a good navigable channel. The widths to which the river is being contracted are given in the section on Widths and Subdivisions. The contraction of the entire flow within a restricted width results in scouring out the bottom to the required depth. On the upper river, where these works are called wing dams, they are built up of alternate layers of brush and stone,—about two-thirds brush and one-third stone,—to a height of 6 feet above mean low water. The first or lowest course projects downstream about 10 feet beyond the others so as to protect the dam from underscour.

On the middle Mississippi the contraction works consist of permeable pile dikes, locally called "hurdles," the piles being driven through a brush mattress having a width of 60 to 100 feet, to protect it from underscour. The piles are driven in clusters of three to four each and each "hurdle" consists of two to three rows of clusters. The rows are about three feet apart, and the clusters 8 to 10 feet part in the rows and staggered with those in adjoining rows. Long slender piles are then laid horizontally between rows, thereby bracing the upper row against the adjoining row. The tops of the piles are left 15 to 20 feet above low water at the channel end and 20 to 25 feet at the band end. The piles vary from 30 to 60 feet in length, according to the depth of the water, and have a penetration of about one-third their length. The wing dams on the upper river cost from $5.50 to $8.50 per lineal foot of dam, and on the middle Mississippi from $20 to $25 per lineal foot. On the lower river no contraction works are being built as the funds appropriated are needed more urgently for levees, bank revetment and dredging.

Dredging and Snagging.

Dredging is carried on extensively to maintain the project depth where improvement works have not yet been constructed, and to supplement the scouring action of the contraction works when the river falls rapidly after a high stage. Most of this work is done by hydraulic or suction dredges, of which there are 8 on the upper river, 4 on the middle division, and 9 on the lower river. The size of the discharge pipe is 12 to 18 inches in diameter, 28 to 32 inches, and 32 to 36 inches, respectively, on the three divisions of the river. The latter have a capacity of 1,000 to 2,000 cubic yards of sand per hour, and the cost varies from five to ten cents per cubic yard. In addition to the suction dredges, seven dipper dredges are in use on the upper Mississippi excavating rock and other hard material, principally on the Rock Island Rapids.

One snagboat above, and two below the mouth of the Missouri, patrol the river during the navigation season to remove snags and other obstructions which are a menace to navigation. To dispose of a snag it is hoisted on deck with machinery, the portions which will float away are sawed off in short lengths, and the heavy mass of roots dropped in a deep pool, deposited below a wing dam, or hauled out on the bank.

Levees.

The main area originally subject to overflow, amounting to 29,790 square miles, begins at Cairo on the left bank and at Cape Girardeau, 51 miles above Cairo, on the right bank. The entire levee system includes about 1,570 miles of levee, of which all but 70 miles are now under construction, affording protection during moderate floods to 26,570 square miles.

Between Cape Girardeau and Rock Island there are additional levee lines aggregating 337 miles in length, but the area protected probably does not exceed 1,000 square miles. The follow-lowing remarks refer to the main area below Cairo.

The first levee was built at New Orleans about two hundred years ago. In 1828 the State of Louisiana took up the matter actively and up to the time of the Civil War had expended about $18,000,000, while Mississippi was a close second with $14,000,000. The total expenditure by individuals, parishes, and states up to that time is estimated by C. G. Forshey, of New Orleans, at

over $41,000,000. During the War and the years immediately following, many breaks occurred, many miles fell into the river, and the remainder became badly deteriorated. Work was gradually resumed but was not pushed actively until the United States began its co-operation in 1882. The volume in place at that time is estimated at 32,000,000 cubic yards. The total volume in the projected system is estimated at 434,000,000 cubic yards, and the total volume now in place about 290,000,000 cubic yards, leaving a balance of about 144,000,000 cubic yards to be completed. At the present time about 20,000,000 to 25,000,000 cubic yards of new work are added each year, and from 3,000,000 to 5,000,000 cubic yards of old work are lost by caving banks.

The standard levee cross-section has a top width of 8 feet and side slopes of 1, vertical, to 3, horizontal. All levees over 12 feet in height are reinforced by a banquet, the top of which is 8 feet below the top of the main levee. The width of the banquet varies from 20 feet for a levee 12 feet high to 40 feet for a levee 20 feet high.

The height of the levees, as a rule, varies from 15 to 25 feet, decreasing to 10 feet near the Gulf, and increasing frequently to 30 feet where they cross old sloughs.

The total amount expended on levees by the United States is about $35,000,000, and by state and local organizations about $100,000,000, or a total of about $135,000,000. The amount of money necessary to complete the system is estimated at $60,000,000 to $75,000,000.

The Passes and Jetties.

At the Head of the Passes, 96 miles below New Orleans, the river divides into three main outlets: Pass a Loutre, which takes about 50 per cent of the discharge and subdivides into three smaller passes; Southwest Pass, which takes about 40 per cent of the discharge, and South Pass, which receives only about 10 per cent.

Much work was done on the bars at the mouths of these passes in attempting to maintain ship channels across them. From 1836 to 1878 about $2,500,000 was expended on various unsuccessful devices and plans. In 1875 Congress authorized James B. Eads to construct jetties and auxiliary works to develop a deep channel in the South Pass. He secured a 30-foot channel

and was paid the contract price of $5,250,000 and $100,000 per annum for maintaining it from 1881 to 1900, inclusive.

The Eads Jetties originally consisted of two parallel structures about 12,000 feet long and 1,000 feet apart. Each jetty was built up of alternate layers of willow fascines and rubble stone, the top width increasing from 10 feet near the shore to 50 feet at the outer end in 30 feet of water. Later a second pair of jetties was built inside the first, 800 feet apart and subsequently spur dikes were added, which contracted the channel still further. The old jetties were surmounted by a concrete wall 4 to 12 feet wide at the base and 5 to 7 feet high. The total length of the South Pass, including the Eads Jetties, is 14 miles.

In order to secure a more commodious channel than that afforded by the Eads Jetties, Congress in 1902 adopted a project for constructing jetties and auxiliary works in the Southwest Pass to develop a channel 1,000 feet wide and 35 feet deep at an estimated cost of $6,000,000.

For economical reasons the jetties were built in shallow water and no attempt was made to keep them parallel except at the outer end. Their distance apart varies from 7,000 to 3,450 feet. Each jetty is built up of willow mattresses about 2 feet thick, each mattress heavily loaded with rubble stone. The mattresses are 150 to 200 feet wide at the bottom and decrease to 35 feet in width at the top, which is covered with a concrete coping 12.0 feet wide and 4.5 feet high, with the top at elevation of mean high tide. The settlement of the jetties has amounted to about 4 feet, which was allowed for in the original construction.

The dredged channel is now about 75 per cent completed, about 25,000,000 cubic yards having been removed, giving a minimum width of 130 feet and a depth on the bar of 30 feet where there was originally only 9 feet. The length of the jetties is 4.5 miles and the total length of the Southwest Pass 19.5 miles.

Cost of Improvement.

The total expenditures by the United States to June 30, 1914, on the improvement of the Mississippi River, including con-

struction, maintenance, and operation of reservoirs, locks and dams, is approximately as follows:

Snagging, St. Paul to New Orleans	$ 4,400,00
Improvement Works and Dredging,	
Above St. Paul	4,300,000
St. Paul to mouth of Missouri River	21,100,000
Mouth of Missouri River to Cairo	16,200,000
Cairo to Head of Passes	46,700,000
Passes	20,300,000
Levees	33,500,000
Total	$146,500,000

The amounts expended by the several states and local interests are not so well known but are roughly estimated at about $100,000,000 for levees and $10,000,000 for docks and revetment works at the larger cities. The hyrdo-electric power development at Keokuk represents an investment of $25,000,000. Smaller water power plants at Rock Island, St. Paul and points further upstream cost many millions more.

Early Navigation.

Following the universal use of the canoe by the Indians and early explorers came the flatboat, piroque, mackinaw boat, keelboat and barge. On account of the hard labor involved in paddling, poling, warping or cordelling against the current, the commerce downstream was always greatly in excess of that upstream. Cheap boats were built on the upper waters of every large river, floated downstream with their produce, and then sold with their cargoes or abandoned. Previous to the year 1817, the whole commerce from New Orleans to the upper country was carried in about twenty barges, averaging 100 tons each, and making but one trip in each year.

The first steamboat built in the Mississippi Valley was the "New Orleans," built at Pittsburgh in 1811. She was 138 feet long, had a capacity of 300 or 400 tons, and cost $38,000. The sixth boat was the "Zebulon M. Pike," built in 1815, the first to ascend the Mississippi above the mouth of the Ohio, and the first to touch at St. Louis (1817). Details of the first sixty-three boats built on the Mississippi and its tributaries are given in

Scharf's "History of St. Louis." The forty-fifth to the sixty-third were built in 1819 and indicate the rapidity with which the new form of navigation was being developed. The boats varied in size from 25 to 700 tons, but most of them ranged from 80 to 300 tons, the most popular size being 150 tons. The "Cincinnati & Louisville Mail Lines," the first line of steamboats organized in the Mississippi Valley, was established in 1818.

On January 1, 1834, an official list gave the total number of steamboats as 230, with an aggregate tonnage of 39,000. The capital invested was estimated at $3,000,000. Of this number 36 steamboats of over 200 tons plied between New Orleans and Ohio River points with an aggregate tonnage of 12,686; 4 in the St. Louis trade with an aggregate tonnage of 1,002; 7 in the cotton trade with an aggregate tonnage of 2,016; 57 boats, not in established trades, from 120 to 200 tons, aggregated 8,641 tons; 126 under 120 tons, in various trades, aggregated 14,655 tons; grand total, 39,000 tons. Besides the steamboats, it was estimated that 4,000 flatboats annually descended the river, having an aggregate tonnage of 160,000. The total number of steamboats built from 1811 to January 1, 1834, was 573; the difference between that number and the 230 in service represents the number worn out and lost—principally the latter.

The Rise and Decline of River Commerce.

In 1842 the number of steamboats employed in navigating the Mississippi and its tributaries was estimated at 450 with an average capacity of 200 tons each, making an aggregate of 90,000 tons. The cost of these boats was estimated at $7,000,000, and the number of men operating them at 35,000. The first company organized to operate a line of steamboats on the upper Mississippi was established that year. The number of steamboat arrivals in St. Louis during that year was 2,412, with 467,824 tons, besides 801 flatboats and exclusive of the daily packets to Alton. At New Orleans the number of arrivals was smaller but the tonnage was larger—550,500 tons, valued at $50,000,000. The number of steamboats lost each year was surprisingly large. In 1846, 36 vessels were lost, of which 24 were sunk by snags and submerged rocks. and the remainder by fire, explosion and collision. During the same year, 108 new boats were built with a tonnage of 51,660 at a cost of $1,450,000.

The transportation of coal down the Ohio and Mississippi, which was destined to develop into such large proportions, began in a small way in the early 'forties. In 1844, it amounted to 737,000 bushels; in 1845, 4,605,000; in 1850, 12,298,000; in 1860, 37,948,000; in 1870, 57,596,000; in 1880, 84,048,000, and in 1886, 109,895,000.

The official returns of St. Louis for the year ending June 30, 1853, show 3,307 arrivals with a tonnage of 45,401. This was exceeded only by the tonnage of New Orleans and New York. In consequence of an unusual low water season in 1860, freight rates on the upper Mississippi, Missouri, and Illinois, ruled very high and the number of marine disasters reached the astounding total of 299. This was followed by a general paralysis of all industries and commerce during the next four years, so that after the Civil War it was necessary to start all over again. In this rebuilding most of the steamboats and barges were built of larger proportions than before the War.

The rise and decline in river traffic is well shown in the following extracts from the annual reports of the Merchants' Exchange of St. Louis:

PORT OF ST. LOUIS.

ARRIVALS					DEPARTURES	
Year	No. of Boats	No. of Barges	Tons of frgt. rec.	Tons of lumber rafted	No. of Boats	Tons of Freight
1860	3,580	1,600	450,000*	No rec.	3,600	400,000*
1865	2,767	1,141	910,000*	" "	2,953	865,000*
1870	2,796	1,195	930,000*	" "	2,782	824,000*
1875	2,201	743	663,525	" "	2,223	639,095
1880	2,871	1,821	893,860	198,315	2,866	1,038,350
1883	2,240	1,185	629,225	231,285	2,140	677,340
1885	1 878	1,030	479,065	217,860	1,828	534,175
1890	1,927	1,274	530,790	132,940	1,910	617,985
1895	2,007	1,126	410,145	98,685	1,904	303,355
1900	1,622	595	438,670	73,340	1,605	245,585
1902	1,465	451	386,045	30,875	1,448	224,261
1905	1,074	385	288,640	1,210	1,057	80,575
1910	559	209	143,540	None	537	48,425
1914	698	38	88 655	"	694	48,935

*Approximate.

There was a decline in river commerce from 1870 to 1877, followed by a revival for a few years, since which there has been a steady decline. The decline on the Ohio and lower Missis-

sippi has also been quite marked but not to so large a degree as at St. Louis. The freight delivered at New Orleans by river in 1909, expressed in tons, was as follows: Coal, 740,000; lumber, 110,000; gravel, 150,000; cotton, 60,000; oil, 40,000; provisions, 38,000; iron and steel, 15,000; passengers, 5,000.

The cause of the decline in river commerce is a mooted question. Primarily it has been due to the more efficient service rendered by the railroads, combined with rate cutting by the railroads in favor of river towns. The latter practice was stopped by the Interstate Commerce Commission but the damage was already done. To the above must be added: (1) uncertainty and irregularity of service; (2) instability of rates; (3) short life of the individual steamboat; (4) lack of effective line organization; (5) extravagance engendered by early prosperity. The likelihood of a revival of river commerce is also a mooted question. If it is accomplished, as many hope and believe it will, it will no doubt be along the lines successfully adopted in Europe; (1) ample and efficient river terminals maintained by the municipalities for use of all boats; (2) the operation in each line of a large number of boats by companies with ample capital working in co-operation with the railroads; (3) the separation of freight and passenger traffic, using fast steel packets with modern accommodations for passenger service, and powerful and efficient towboats with covered steel barges for freight traffic.

Bibliography.

For explorations, history and description, see Shea, "Discovery and Exploration of the Missisippi Valley" (1853); Mark Twain, "Life on the Mississippi" (1883); Glazier, "Down the Great River" (1887); Scharf, "History of St. Louis" (1883); Could, "History of River Navigation" (1889); Glazier, "Headwaters of the Mississippi River" (1897); Brower, "The Mississippi and Its Utmost Source" (1897); Parkman, "La Salle and the Discovery of the Great West" (1898); Ogg, "The Opening of the Mississippi" (1904); Griffin, "Bibliography of the Discovery of the Mississippi River," in Joutel's "Journal of La Salle's Last Journey" (1906); Matthews, "Remaking the Mississippi" (1909); Chambers, "The Mississippi River and Its Wonderful Valley" (1910). For floods, levees, commerce, physical characteristics and engineering features see Humphreys and Abbot,

"Physics and Hydraulics of the Mississippi River" (1861) ; Eads, "Physics and Hydraulics of the Mississippi River" (1876) ; Corthell, "History of the Jetties at the Mouth of the Mississippi River" (1880) ; Dawson, "Notes on the Engineering Works of the Mississippi River" (1900) ; Tompkins, "Riparian Lands of the Mississippi River, Past, Present, Prospective" (1901) ; Thomas and Watt, "The Improvement of Rivers" (1913) ; Van Ornum, "The Regulation of Rivers" (1914) ; Humphreys, "Floods and Levees of the Mississippi River" (1914) ; "Report on Survey of Mississippi River from St. Louis to Its Mouth" (1909), House of Representatives, Document No. 50, Sixty-First Congress, First Session; "Transactions, American Society of Civil Engineers" (1867 to 1914) ; "Journal of the Association of Engineering Societies" (1881 to 1914) ; "Reports and Communications, Permanent International Association of Navigation Congresses" (1885 to 1912) ; "Professional Memoirs, Engineer Department, U. S. Army" (1909 to 1914) ; "Annual Reports of the Chief of Engineers, U. S. Army" (1866 to 1914) ; "Annual Reports of the Mississippi River Commission" (1879 to 1914) ; "The Mississippi River from St. Louis to the Sea" (40 maps, 1 inch = 2 miles) (1892) ; "Detail Charts of the Lower Mississippi from the Mouth of the Ohio River to the Head of the Passes" (Nos. 3 to 88, inclusive, two scales, 1 inch = 1 mile, and 1 inch = 1,666 feet) ; "Detail Charts of the Upper Mississippi River from the Mouth of the Ohio River to Minneapolis" (Nos. 101 to 189, inclusive, scales same as above) ; "Detail Charts of the Upper Mississippi River from Minneapolis to Its Headwaters" (Nos. 210 to 278, inclusive, scales same as above).

[NOTE.—Further discussion of this paper is invited, to be received by Joseph W. Peters, 3817 Olive Street, St. Louis, for publication in a subsequent number of the JOURNAL.]

ASPHALTIC AND BITULITHIC PAVEMENTS

COST OF RAW MATERIAL AND COST OF MIXING

By R. S. Dulin.*

[Read before the Oregon Society of Engineers, May 19, 1915.]

In presenting these cost data in regard to bituminous pavements, I will cover the cost of the raw materials actually entering into the various bituminous and concrete pavements as laid under the standard specifications of the City of Portland, as well as the cost of mixing bituminous pavements. Mr. McMullen, who had had thirteen years' experience with the laying of hard surface pavements, will enter into the costs of haul, scarifying of old foundation and laying of the pavement.

On May 11th, 1914, the City Council passed ordinance Number 28,915, which provided for standard specifications for the various kinds of pavements that might be laid in the city. Early in 1915, I prepared laboratory samples of the various kinds of bituminous pavements in strict accordance with the standard specifications and secured comparative cost data concerning the materials in the various pavements.

The unit prices used for the various ingredients in the pavement mixtures have been taken as the same for the same materials no matter in which pavement they were used, so that the cost data for the various pavements are strictly comparable and furnish good means of comparison with each other. Any deviation that would occur in practice in laying these pavements due to uneven sub-grade, et cetera, will affect all pavements alike and does not vitiate these comparative data.

The order in which these pavements will be discussed, will be asphaltic concrete on three inch bituminous base; gravel bitulithic on three inch bituminous base; asphaltic concrete on four inch crushed rock base; bitulithic on five inch concrete base; bitulithic on four inch crushed rock base; sheet

*Chief of the Bureau of Standards, Dept. of Public Works, Portland, Oregon.

asphalt on five inch concrete base; asphaltic concrete redress on one and one-half inch crushed rock base; five inch concrete pavement based on a 1-2-4 mixture; Hassam, Class A, six inches, and Class B, five inches thick.

Asphaltic Concrete Wearing Surface.

Asphaltic concrete wearing surface, one and one-half inches thick on a one inch binder. The proportions of the various materials used in the preparation of the samples of asphaltic concrete wearing surface and binder were made as near the mean of the proportions required by the specifications as possible. The following statements show the limiting proportions of the various ingredients and materials required by the specifications for the asphaltic concrete wearing surface, the mean of the various proportions actually used in the sample, the weight in pounds of the various ingredients used in the batch from which the sample of asphaltic concrete was made.

PROPORTIONS OF ASPHALTIC CONCRETE WEARING SURFACE:

Material	Limits Specifs.	Mean	Actual Prop'rt'n	Wght. in Mixt. lbs.
Rock passing ½″ screen	5 to 9%	7.0%	7.0%	70
Rock passing ¼″ screen	27 to 31%	29.0%	29.1%	292
Sand passing 10 mesh screen	13 to 17%	15.0%	14.9%	150
Sand passing 40 mesh screen	28 to 33%	30.5%	30.6%	308
Filler passing 200 mesh screen	6 to 10%	8.0%	8.0%	80
Asphaltic cement	9 to 12%	10.5%	10.4%	105
			100.0%	1,005

The specific gravities of the component parts were found to be as follows:

Rock	2.85
Sand (passing 10 mesh screen)	2.69
Filler	3.10
Asphaltic Cement	1.06

Now, it is well to explain here that the high specific gravity of the sand is due to a considerable proportion of fine crushed rock that has a specific gravity of 2.85 and is fine enough to pass the 10 mesh screen. The filler used was Portland cement, with 3.10 specific gravity.

The aggregate in the trial batch weighed 900 pounds and when well mixed and compacted, was found to have a volume of 6.96 cu. ft. If this aggregate were absolutely voidless and possessed the density indicated by the specific gravity of its component parts, the volume would be 5.17 cu. ft.

Hence: $\frac{6.96 - 5.17}{6.96 \times 100} = 25.7\%$, which indicates the percentage of voids in the aggregate.

The specific gravity of the aggregate was found to be: $\frac{900}{5.17 \times 62.4} = 2.79$.

One hundred and five pounds of asphaltic cement was next added to the 900 pounds of aggregate, and complete samples of asphaltic concrete wearing surface were made. Tests of these samples indicated that the completed wearing surface had a specific gravity of 2.316.

If this completed wearing surface had been made absolutely voidless and possessed the specific gravity of its component parts, the batch of 1005 pounds would have occupied 6.76 cu. ft. This would give a specific gravity equal to: $\frac{1005}{6.76 \times 62.4}$, or 2.38, for a voidless pavement.

Hence: $\frac{2.38 - 2.316}{2.38 \times 100}$, or 2.69, indicates the percentage of voids actually existing in the completed wearing surface.

Since the aggregate alone possessed a specific gravity of 2.79, and the completed wearing surface had a specific gravity of 2.316, the specific gravity of the finished wearing surface was equal to 83 per cent of the aggregate.

The weight of one cubic foot of this finished wearing surface was equal to:

2.316x62.4 or 144.5 pounds.

Hence the trial batch of 1005 pounds would lay: $\frac{1005}{144.5}$ or 6.9 cu. ft. of pavement.

As a wearing course 1½ inches thick requires 1.125 cu. ft. of pavement, the batch of 1,005 pounds would lay:

$\frac{6.9}{1.125}$ or 6.1 sq. yds. of 1½-inch wearing surface.

The following table shows the cost of the materials (at the bunkers of the paving plants) comprising the batch of

1005 pounds from which 6.1 sq. yds. of asphaltic concrete wearing surface 1½ inches thick may be made:

Material		Weight in lbs.	Vol. in cu. ft. as measured at bunkers	Cost at prevailing prices at bunkers	Total cost material in batch of 1005 lbs.
Filler	Rock Dust	60	.60	$ 1.00 per c. y.	.022
	Cement	20	.20	6.00 per ton	.060
Sand	Rock Screenings	144	1.37	1.00 per c. y.	.050
	Sand	314	2.99	.70 per c. y.	.077
Asphaltic Cement		105	1.59	10.50 per ton	.551
Rock		362	3.51	1.00 per c. y.	.130
					.890

These prices are the prices that the City was paying at the beginning of 1915. I do not know whether or not they have changed since then.

This table may be explained in a shorter way, when the materials are classified simply as rock, sand, Portland cement and asphaltic cement:

Material	Percentage in batch	Cost
Rock	56.3	0.202
Sand	31.2	0.077
Cement Filler	2.0	0.060
Asphaltic Cement	10.5	0.550
		Total 0.889

In the laboratory samples as actually constructed, the filler was entirely composed of cement, but actual analysis of pavements laid in the City show that 75 to 100 per cent of the filler is ordinarily composed of rock dust, so the cost data have been prepared on the supposition that the filler is composed of 75 per cent rock dust and 25 per cent cement. Now, 6.1 sq. yds. of asphaltic concrete wearing surface 1½ inches thick may be made from this trial batch of 1005 pounds, the material for which cost $0.89 or $0.146 per sq. yd. of finished wearing surface.

Binder Course.

Making a similar study of the binder course which is one inch thick and laid under all asphaltic, concrete and sheet

asphalt pavement wearing surfaces, we find that the cost of materials for binder in a batch of 1055 pounds is as follows:

Material	Weight in lbs.	Vol. in cu. ft. as measured at bunkers	Cost per cu. yd. at prevailing prices at bunkers	Total cost material in batch of 1055 lbs.
Rock	682	6.14	$1.00	$0.227
Sand Screenings	100	0.95	1.00	0.035
Sand	218	2.08	0.70	0.054
Asphaltic Cement	55	0.83	10.50 ton	0.289
	1055			$0.605

When the materials are classed simply as rock, sand and asphaltic cement we find their respective percentages and costs to be as follows:

Material	Percentage by weight	Cost
Rock	74.1	$0.262
Sand	20.7	0.054
Asphaltic Cement	5.2	0.289
		Total $0.605

Nine and four-tenths sq. yds. of asphaltic concrete binder one inch thick may be made from this trial batch of 1055 pounds, the materials for which cost $0.605, or $0.064 per sq. yd. of finished binder.

Bitulithic Wearing Surface.

The following study shows the cost of the material at the bunkers of the paving plant, comprising the batch of 1085 pounds from which 4.7 square yards of bitulithic wearing surface two inches thick may be made:

Material		Weight in lbs.	Vol. in cu. ft. as measured at bunkers	Cost at prevailing prices at bunkers	Total cost of material in 1085 lbs.
Sand	Rock screenings	88	.84	$ 1.00 per c. y.	$0.031
	Sand	192	1.83	.70 per c. y.	0.047
Filler	Rock Dust	41	.41	1.00 per c. y.	0.015
	Cement	14	.14	6.00 per ton	0.042
Rock		665	5.99	1.00 per c. y.	0.222
Asphaltic Cement		85	1.29	10.50 per ton	0.446
					$0.803

When the materials are classed simply as rock, sand, Portland Cement filler, and asphaltic cement, we find their respective weight, percentages and costs to be as follows:

Material	Percentages by weight	Cost
Rock	73.2	$0.268
Sand	17.7	0.047
Filler	1.3	0.042
Asphaltic Cement	7.8	0.446
		Total $0.803

In the laboratory samples as actually constructed, the filler was entirely composed of cement, but actual analysis of pavements laid in the city shows that from 75 to 100 per cent of the filler is ordinarily composed of rock dust, and the cost data have been prepared on this basis. We supposed that 25 per cent would be Portland cement for filler, or something that would cost about the same thing. Some of the limestone fillers would cost about the same. The cost of the filler would be $6 per ton. Portland cement is variable in price. The Portland cement used for filler would probably be some damaged cement and it is supposed that the contractor would not have to pay as much for that filler as he would have to pay for the cement that is to be used in the other work.

Four and seven-tenths sq. yds. of bitulithic wearing surface two inches thick may be made from this trial batch of 1085 pounds, the material of which will cost $0.803, or $0.171 per sq. yd. of finished wearing surface two inches thick.

Sheet Asphalt Wearing Surface.

The cost of materials in a batch of 1136 pounds was found to be as follows:

Material	Weight in lbs.	Perc. by Wght.	Vol. in cu. ft. as measured at bunkers	Cost at bunkers	Total Cost
Sand	866	76.2	9.46	$ 0.70 per c. y.	$0.245
Filler (cement)	134	11.8	1.25	6.00 per ton	0.714
Asphaltic Cement	136	12.0	2.06	10.50 per ton	0.402
					$1.361

Hence, the materials in a batch of 1136 pounds may be secured at a cost of $1.361, from which 5.8 square yards of

wearing surface two inches thick may be made, or at a cost of material of $0.235 per square yard.

The bituminous base, three inches thick was worked out in about the same manner. It is hardly necessary to go through all the details, which were worked out on the same basis.

Concrete Pavements and Base.

For five inch concrete base, the specifications require that 1-3-6 mixture be used, the maximum size of gravel being two and one-half inches in any direction. The method of calculation depended on the use of Fuller's formula for determining the amount of sand, rock and gravel and the number of barrels of Portland cement. The formula shows that 1.1 barrels of Portland cement, 0.47 cubic yards of sand, and 0.93 cubic yards of gravel are required to secure one cubic yard of concrete having these proportions. The cement was figured at the present price of $1.70 per barrel and the sand and gravel both at $0.75 per cubic yard. This makes a cubic yard of this mixture cost $2.85 for materials.

Inasmuch as a cubic yard of concrete, the material of which cost $2.85, will lay 7.2 square yards of concrete base five inches thick, the cost of materials in a five inch base is $0.396 per square yard.

The concrete pavement was calculated in the same manner, for the various thicknesses. My estimates for the costs of the materials in twelve different types of pavement are summarized in the following table:

Summary of Cost Data for Pavements.

The following table has been so arranged that pavements which are naturally competitive with each other have been arranged consecutively. The comparative cost of the materials for wearing surface, binder, base, and entire pavement are here given for 12 different types of pavements.

TABLE OF COST OF MATERIALS PER SQUARE YARD OF FINISHED PAVEMENT.

TYPES OF PAVEMENTS	Specifications No.	Wearing surface 2 ins. thick	Wearing surface 1½ ins. thick	Binder 1 in. thick	Bituminous base 3 ins. thick	Crushed rock base 4 ins. thick	Crushed rock base 1½ ins. thick	Concrete base 5 ins. thick	Tl. cost of mat. per sq. yd. of finished pavement
Asphaltic Conc. on Bit. Base	123	$0.195	....	....	$0.189	....	....	....	$0.384
Grav. Bitulithic on Bit. Base	132	0.171	....	....	0.189	....	....	....	0.360
Asphal. Conc. on Cr. Rk. Base	122	....	$0.146	$0.064	....	$0.180	....	....	0.390
Bitulithic on Cr. Rk. Base	131	0.171	....	....	....	0.180	....	....	0.351
Asphal. Conc. on Conc. Base	121	....	0.146	0.064	....	....	....	$0.396	0.606
Bitulithic on Conc. Base	130	0.171	....	....	....	....	....	0.396	0.567
Sheet Asphal. on Conc. Base	120	0.235	....	0.064	....	....	....	0.396	0.695
Asphal. Conc. Redress	124	....	0.146	0.064	....	....	$0.089	....	0.229
Bitulithic Redress	133	0.171	....	....	....	....	0.089	....	0.260
Conc. Pavement (1-2-4 mix.)	104	....	....	....	....	....	....	....	0.690
Hassam Class "B"	105	....	....	....	....	....	....	....	0.604
Hassam Class "A"	105	....	....	....	....	....	....	....	0.709

Cost of Mixing Bituminous Pavements.

Probably, the data dealing with the cost of mixing bituminous pavement which will prove of most interest to the persons here present are those which I have secured from John R. Penland, City Engineer of Albany, Oregon, who has kept complete cost data for the laying of bituminous pavements. Between August twelfth and October twenty-second, 1914, 17,035 square yards of asphaltic concrete wearing surface one and one-half inches thick on three and one-half inch bituminous base were mixed at the following costs per square yard for labor and fuel:

The total cost was $441.33 for fuel oil, or at the rate of $0.026 per square yard; $89.35 for cordwood was used at the plant, or at the rate of five mills per square yard. The total cost of labor was $1373.46,—that is for plant labor only,—or at the rate of 8.1 cents per square yard, making a total cost of 11.2 cents per square yard for mixing. This is, of course, the cost of mixing for a five inch pavement. Now, figuring on the cost of a two inch wearing surface the rate would be four and five-tenths cents.

(For discussion, see page 79).

ASPHALTIC AND BITULITHIC PAVEMENTS

COST OF GRADING, HAULING, SPREADING, ROLLING, Etc.

Mr. R. G. McMullen.*

[Read before the Oregon Society of Engineers, May 19, 1915.]

Inasmuch as Mr. Dulin has gone through the cost of the raw material in his discussion, he has left a large part of the work for me, such as making the road, hauling, scarifying roads, shaping, spreading, rolling, etc. From the cost data in our hands in regard to making the asphaltic concrete mixture, or these others that have been referred to, we find the cost of mixing one square yard of bituminous pavement two inches thick to be 6c per square yard.

The cost of hauling is based on the ton-mile basis, using auto trucks of five tons capacity. The cost of operating one five ton truck, as compiled from the records kept by Multnomah County for the past year is as follows:

Salary of driver per day	$3.50
Wear on tires per mile	.05
Depreciation on truck per mile	.04
Repairs to truck per day	2.00

Gasoline consumed at the rate of four miles to one gallon, lubricating oil at 80 miles to one gallon, grease at 10c to 15c per day, interest on the original cost of truck, 6 per cent.

We figure the repairs to truck at $2.00 per day for every day in the year, making $732 per year. From the above unit prices the cost per ton mile has been calculated and shown by the County Records to be as follows:

One mile	.161c
Two "	.250
Three "	.355
Four "	.465
Five "	.562
Six "	.630
Seven "	.680
Eight "	.728
Nine "	.768
Ten "	.800

*Assistant Engineer, Department of Public Works, Portland, Oregon.

The tabulation given by the County is for 1 cu. yd. which weighs from 2800 to 3100 lbs. Reducing the cost of haul from the cu. yd. basis to the ton-mile basis, we find the cost will average for a 7½ mile haul $0.572 per sq. yd. One ton of mixed material will lay 9 sq. yds. of pavement, 2 inches thick, after compression. Therefore, for convenient reference, a rate of 1 cent per mile for 1 sq. yd. of pavement is enough to cover cost of haul.

The cost of hauling crushed rock for a base 1½ inches thick, used for spreading over old macadam, would be for a 7½ mile haul, $.038 per sq. yd.

The cost of scarifying old macadam would be $.06 per sq. yd.

The cost of spreading and rolling new base, 1½ inches thick, would be $.028 per sq. yd.

The cost of spreading and rolling the top or wearing surface, 2 inches thick, would be $.06 per sq. yd.

In addition, we have added 20 per cent to cover overhead charges, accounting and incidentals, which makes the total cost of laying pavement by County work, $0.599 per sq. yd.

There will be considerable fluctuation in the percentage added, as the details of some parts of the work will cost more, and some less, than 20 per cent.

In addition to all the costs referred to, an additional cost has been added, that of 10c per cu. yd. for the handling of the raw material at the mixing plant, as some of the material has to be moved 50 or 60 feet from stock piles to the mixer.

We have prepared a table of all detail costs in cu. yards and sq. yards for the different Multnomah County roads, and we have filed a copy with the Board of County Commissioners, which is now of public record and open to inspection. In addition, we filed a detailed statement of the cost of paving Sandy Road, it being the road farthest from the County Quarry at Kelly Butte. The other roads contemplated for paving being much nearer, so that the cost of haul is reduced on each of the subsequent roads. The extreme on the Sandy Road being out near Troutdale. The Sandy Road haul is a maximum of 11 miles, the shortest haul being 4 miles and the average being 7.5 miles. Some of the remaining roads are about 2 miles from Kelly Butte.

Our data is based upon facts we have obtained from others at different places where these things have been done. I happened to pick up a copy of the Engineering News the other day and found figures in substantiation of our estimate of costs. The issue of the Engineering News is that of May 13th, 1915, and the article I refer to is found on page 941, where it quotes Mr. H. E. Hilts, Engineer of the Association of American Portland Cement Manufacturers, which maintains a corps of inspectors and engineers whose services are furnished the cities, counties and states, constructing concrete highways; to the end that the work may be carried out in such a manner as to produce a satisfactory and durable roadway. In a paper entitled "Cost and Economy of Cement Concrete Pavement," read at the Cornell Good Roads Convention, Mr. Hilts presented some valuable figures, showing the average cost of 1,500,000 sq. yds. of concrete pavement laid on roads and streets in 1914, under the inspection of the Association. These figures represent work performed on 95 different contracts in 20 different states. A table by Mr. Hilts, published in the Cornell Civil Engineer for March and April, gives an average cost per sq. yd. for the 1,500,000 sq. yds. of pavement of $1.058. It should be noted that this is actual cost and does not include the contractor's charges for overhead charges and profits. The figures from states where only a small amount of concrete pavement was laid are of comparatively little importance, as special conditions may have caused certain items in the cost to be abnormally low or abnormally high. The figures from such states as New York, with 730,000 sq. yds., Connecticut with 200,000 sq. yds., and Iowa with 90,000 sq. yds., represent enough work to make the itemized figures valuable.

It is of interest to notice, as an illustration of the efficiency with which the building of concrete roads is now performed that of the total cost of the paving 70 per cent is the cost of materials, leaving 30 per cent, or a little over 30c per square yard for the entire cost of the labor, the hauling of the material and the use of the mechanical equipment on the job. In other words, the cost of the raw materials was $0.74 and the cost of the labor, $0.31, making a total of $1.05. Ordinarily the concrete pavement is 6 inches thick, while the bituminous pavements are 2 inches thick and the materials in the bitu-

minous pavements are not so expensive as they are in the concrete pavements. These figures, therefore, bear us out in our contention, that two inch bituminous pavements can be laid for $0.60 per sq. yd., including overhead charges, etc., or at an actual cost of $0.532.

The reference is the average cost for one million and a half yards, as laid in eighteen different States, viz: Wisconsin, Ohio, New York, Connecticut, Indiana, Illinois, Iowa, Maryland, Massachusetts, Michigan, Missouri, making a fair average of costs throughout the United States.

DISCUSSION

The President. I am sure that we have been much interested in what these gentlemen have had to tell us concerning the cost of bituminous pavements. We have many here who are interested in the subject and who would without doubt like to discuss the matters brought out by these two papers, and to ask some questions of the authors of the papers, which, I am sure, they will gladly answer.

Mr. R. G. Dieck (Commissioner of Public Works, Portland). Before there is any discussion of the paper of this evening, I wish it to be understood that the statements and sentiments expressed are not approved by the Department of Public Works. As long as it has been announced that the two gentlemen who addressed us are employees of the Department of Public Works, the stand of the Department in regard to what they may say ought to be known.

Mr. Stevens. I would like to ask whether these costs of hauling, and of placing the preparation on the road, have been arrived at by means of work that has actually been done.

Mr. McMullen. The cost of scarifying the road is arrived at in two or three different ways. In the past years, the city of Portland has let a great number of contracts for hard-surfacing macadam roads, containing from eight to ten inches of macadam. This old macadam material had to be "rooted" up, excavated and hauled away. About the highest bid the city of Portland ever received was $0.75 per cu. yd. for breaking up, removing and hauling away this old macadam material. 18 sq. yds. of roadway surface may be scarified to a depth of two inches per each cu. yd. of material removed. Our estimated cost of six cents (6c) per

sq. yd. for scarifying is at a rate of $1.08 per cu. yd. In scarifying a road we do not have to pick it up and haul the material away, as we do in the case of paving old macadam roads, for the surplus material can be deposited alongside the roadway. Therefore, it is a question of $0.75 per cu. yd. for scarifying by contractors' bids as against $1.08 per cu. yd. as allowed in our estimate of six cents (6c) per sq. yd., so, I consider our estimate for scarifying as sufficiently high.

Mr. Stevens. That explains the cost of preparation of the roadbed. You also gave a price of six cents for mixing. Where do you get those figures? Were those figures arrived at from actual cost of work done in the past?

Mr. McMullen. Yes, sir. The cost given in this list, which I have here, I have found to be correct from my own notes, that I have taken in the past. Even then, I find by comparison with cost data from other cities, that I am still pretty high. The actual cost that was found to be incurred in work done under Mr. John R. Penland, the City Engineer of Albany, Oregon, is lower than the prices I have given here. Taking his record, we find that the total cost for mixing is as follows:

For fuel and oil	$.026 per sq. yd.
For cordwood	.005 per sq. yd.
For plant labor	.081 per sq. yd.
	$.112

This is the total cost of mixing aphaltic concrete pavement, five inches thick, consisting of 3½ inch bituminous base and 1½ inch wearing surface. Assuming that the cost of mixing varies as the thickness of the pavement, the cost of mixing for a two-inch wearing surface would be $0.045 per sq. yd.

Mr. Stevens. Now, of the total cost for the pavement, as it is finished, what is the percentage of cost for labor and what percentage is cost of material, in some of your estimates?

Mr. McMullen. We have not that segregated. At least, we haven't segregated it in estimating the cost of bituminous pavement.

J. P. Newell. Do your cost figures include interest and depreciation on plant?

Mr. McMullen. They do. My figures include 6 per cent interest and 10 per cent depreciation on the plant.

MR. W. B. WARREN, Vice-President of Warren Brothers Company. I would like to know how the price, the cost of materials and the cost of labor compare with the contractor's cost for the same thing.

MR. McMULLEN. The contractor's costs are, in many respects, different from ours. IN THAT WE ARE NOT CONTRACTORS, WE HAVE NOT TAKEN INTO CONSIDERATION MANY THINGS THAT THEY DO.

MR. W. B. WARREN. You admit that there are many things that the contractors have to take into consideration, which you do not consider at all?

MR. McMULLEN. There are many questions on the contractor's side that we do not take into consideration. We were speaking of the actual cost of laying this pavement, and we do not consider the question of profit in the matter at all.

MR. W. B. WARREN. You ought to know, however, just what you would contract that same thing for.

MR. McMULLEN. The prices that the contractors have bid on the different pavements are on record in the City Hall, and if you will take the trouble to look at them, you will find that these bids range from $1.04 to $1.95.

MR. W. B. WARREN. Were those figures compiled from the records, and with regard to the central paving plant at Kelly's Butte?

MR. McMULLEN. Yes, sir.

MR. W. B. WARREN. With regard to depreciation, I would like to ask you if you do not think that 10 per cent depreciation on paving plants and on crushing plants is a little bit small.

MR. McMULLEN. No; I do not think so.

MR. W. B. WARREN. Do you figure in any liability insurance? Do you consider anything of that sort?

MR. McMULLEN. That is all covered.

MR. W. B. WARREN. As to the cost of materials that would go to make up different pavements, I think you will find, as it seems to me, that there is a certain amount of theoretical headwork about this. There is considerable difference in the working out of it in a practical way, you will find, from your theory. I noticed this particularly in Mr. Dulin's paper, discussing the cost of material. He takes, for instance. the cost of rock in bunkers at $1.00 per cu. yd. And he takes the cost of asphalt at

$10.50 per ton, and then he figures out how much material would be in the pavement, how much material he could put in there at those prices. I do not think that he would reach the figures that he did and the conclusions that he gave, if he figured this out the way he should. In practice, I believe, he would find that it would not work out, in a good many instances, in the way that he has attempted to work it out on paper here. For example, I would like to point out his figure on rock of $1.00 per cu. yd. in the bunkers. He does not figure on the amount of moisture that the rock in the bunkers will contain. Rock, when it is wet, is of a different nature than rock when it is dry. When it is wet, and when they have crushed it, it holds 15 per cent of moisture. That in weight, per cu. yd., assuming that the weight of it will be 2,700 lbs., would be quite an item, and the amount of moisture makes considerable difference. When you reduce the cu. yd. to its actual weight, when it is dry, you will find that there is an actual loss to the contractor, of from 15 to 20 per cent. Now, there is another point in the matter of asphalt that was overlooked, and he will find some difference between his theoretical figures, and the actual facts, when he gets to working on them. Asphalt at $10.50 on the dock does not mean asphalt at $10.50 as actually used. This is true, because when you come to buy a ton of asphalt, at least 10 per cent of it is wood, of the barrel staves, and also a considerable amount of it sticks to the barrel, and, when the contractors who have bought a considerable amount of it, come to figure out at the end of the year what they should have consumed, they will find that they have used just about 10 per cent more than they thought they needed, theoretically.

Again, you can, theoretically, figure out that you can get just about so much out of a cu. yd. of material on the street, whether it is on a concrete base or crushed rock foundation. In actual practice, you will find that you cannot get 4.7 sq. yds. to the batch of 1,085 lbs. of bitulithic pavement. You will find that the actual yardage runs between 3.9 and 4.1, making a loss of 20 per cent. You will find that that is due to the fact that some of the material goes down in between the stones of the foundation. The bituminous top will necessarily be about 2 inches thick and the fact that some of this leaks down in between the stones, makes a result that there will be a possible thickness of 2½ inches. In this way, you will lose one-half inch or more of material and though it is

supposed to work out, theoretically, on this basis, it does not work out that way when it comes to actual practice, and, the extra thickness is a loss to the contractor, if he merely figures theoretically, instead of figuring on the cost of actual conditions to be met with in building the road.

So, I would like to point out that the figures he has given for the costs of these materials seem to indicate a lack of practical knowledge of the use of these materials, and seem to me to be entirely erroneous, as it is theoretical figures that he has been working on; but when you get through theorizing, and figuring, and compare his figures with the actual cost, to a contractor, you can see the reasons for the differences, and, why his theoretical figures are entirely erroneous.

I want to say, also, that in the matter of cost, all the way through, you will find that his figures are, correspondingly, too low. I would like to mention in particular, where, if I understood him, he figures the cost of 5 inches of pavement in Albany, Oregon, and then, since he wanted to have only a 2 inch top, he figured that by taking two-fifths of this he would get the cost of the laying of the pavement as he wanted it here. Now, I want to say right here that I do not believe that that would give the cost of laying the surface here. The cost of laying the binder 4 inches thick is less than the cost of laying a 2 inch thickness. That, is entirely a theoretical way of figuring it out, and it does not represent the actual cost by any means.

Besides the above, I am sure that there are many items which were not intentionally overlooked, but which have, nevertheless, been left out. I am sure that there have been overlooked numerous items in figuring the cost of this road building, as is made evident by looking at the final results that are reached, because a road cannot be built for any such figures as have been given. The difference is made up by the omission of several items.

For instance, take the matter of liability insurance. In actual practice, you will find that you cannot carry it without having an added cost of 2c per sq. yd. There are also some additional charges for sundry items that have to be carried. The matter of liability insurance on one road was $0.07 per sq. yd. Now this item is entirely omitted. It is apt to be overlooked by everybody except the man who has to put his hands in his pocket and pay it. There are, also, at least twenty items which I am sure a con-

tractor would have to pay for, which are not mentioned there at all. They are not covered by your costs. If they were put in there, I think that you would find that your figures would add up to just about what I say they should be.

Now, take another matter, that of repairs to the plant. Whatever he figured in as the cost of repairs to the plant, he certainly did not put the amount at a sufficiently large figure. For your information, I will state that the repairs to the plant on the road where crushed rock is used run very often as high as $.09 per sq. yd. for the year, due to the burning out by excessive heat. This could not be figured from a 10 day operation, or even from a 20 day operation. You will find that needed repairs to plant will run from $.05 to $.06 per sq. yd.

Then, there is the matter of bond premiums. Interest on the investment must be considered also. You must remember that you have to borrow money to carry out the work, and, while you are waiting three, four or five months for the money, you must pay interest on it. That is one of the differences between the theory and the actual practice in this kind of work.

Then again, there is the matter of haul. The depreciation on an automobile truck used for this kind of work is a very large item. Anyone who has used an automobile truck for this kind of work (handling hot material) will agree with me in this. He says that you can haul 10 miles on Sandy Road for $.80. This is the cost for hauling a ton to Sandy Road, but, we find that the figures are not in keeping with our own actual experience. I might say that, in fact, it is a large percentage too short of the actual cost of the haul. Knowledge of actual conditions only come to those who have gained experience in trying to hire an automobile truck to do this kind of work. Very often you will find that a man will theorize about what he will do, but he will fall down very hard when he comes to do it.

I would estimate, from the experience that I have had in hauling hot materials of the kind used in this sort of work, (bituminous materials) that in hauling it over a road and hauling crushed stone, the cost of hauling, from Kelly's Butte for 15 miles, will run as high as $.45 per sq. yd. The total cost of haul so far as I was able to hear from his paper, was to be $.05 per sq. yd., and my idea of the cost of hauling 10 miles would be $.45 per sq. yd. Now, we are putting in about 25 miles of road, and

in order to get this material to the place where it is needed there will be something like 15 miles average haul, but it is entirely impractical to attempt to haul more than 6 or 8 miles. It is not because it can't be done with automobile trucks, but, it is a waste of good money to try to haul more than a few miles, because the cost runs up so high as to be prohibitive.

Now, I gather from what Mr. McMullen has said, the cost of a 2 inch wearing surface, similar to ours, such as asphaltic concrete or sheet asphalt, is no greater than the cost of concrete. Now, in giving the figures that way, he is relying on a purely theoretical consideration of the situation, and, he will find from actual experience, that asphaltic pavement will cost considerably more. That is the reason why you never see an asphalt sidewalk; because a concrete sidewalk can be laid considerably cheaper. It is very easy for you to work out on a piece of paper that asphalt sidewalks are cheaper and that asphalt itself is cheaper, but you cannot, from actual experience, come to the same conclusion. You cannot say from experience that an asphalt surface, which is only one-third the thickness of this concrete, will cost only one-third as much. This method of figuring is erroneous, and has no relation to the actual expense of bituminous pavements, even in sheet asphalt pavement, which is the cheapest, because sand is used.

The cost of scarifying, which you mention in your paper, is much less than we have found it to be from actual experience. It may be that we did not have the right methods. We haven't been able to get your costs for scarifying roads, preparatory to laying pavement, but we have certainly had experience, and have employed the cheapest methods we knew of.

The total cost of laying roads is at least 30 per cent more than your estimate, also. Of course it may be that others can do it cheaper than we can, but we try to do it as cheaply as we possibly can.

In regard to the question of the delivery of cement: Cement is to be had at $1.70 F. O. B. Portland, and the cost of delivery is an item of expense which is not taken care of. I have never found any price such as $1.70 for cement delivered on a piece of work during the past two years.

On the basis of figuring up the cost of asphalt and bitulithic pavement, which you have used, which was 8.5 per cent of asphal-

tic cement,—85 lbs. per 1,000 lbs.—is 10 per cent less than is actually used. We have found that we use 95 lbs. of net material. The difference between 95 lbs. and 85 lbs. is equivalent to 12 per cent. The amount that is figured here, that you could get from a cubic yard of binder, is not correct. The irregularity in the surface of the concrete and grade makes you lose a considerable portion of the material over the theoretical computation. In making your figures you did not take such actual conditions into consideration at all.

The figuring of the cost for a ten day run in Albany, from the 12th to the 22nd day of August, brought to mind the fallacy of trying to figure from a ten day run. In the first place, the yardage was large. The average contractor would not lay that much in a month and a half. He may do that much in one month and the next month he may be idle half of the time, and, not accomplish nearly as much. The item of idle time was overlooked. It is a fact that you must take into consideration that there will be some irregularities in the times in which you can work. You cannot lay a man off one day and then when the fair weather comes and the rain has stopped, expect to get him back and continue on with him. You must figure on keeping him whether the weather is good or bad and whether you can work him or not, and you must at times be paying out money to him even though he does not work, in order that he may supply his family with bread and butter. To get at this correctly you must figure your payroll for the entire year and you must take into consideration the matter of the full year for your superintendents. The cost of superintendence of such a job, when properly handled, includes the cost of office expense which runs about $.10 per sq. yd., and, that is considerably more than would be expected from a theoretical standpoint.

They did not speak of the office expense, or the overhead expense at all, in the paper under discussion. The items of plant site preparation, plant installation, fire insurance, laboratory expense and the cost of surface finish, which latter item, with asphaltic concrete (bitulithic) amounts to about $.05 per sq. yd., has been omitted, as well as legal expense. They overlooked other items, which would bring up the cost to at least one-third more than they have figured it to be theoretically. For a contractor to omit any of these items would be fatal, and, it would amount to

just the difference between being able to accomplish a good job and break even, to getting in the hole and losing considerable money.

I think it is due to the gentlemen to say, that it is not their fault, and that their miscalculations have been due altogether to a lack of experience. It is the common experience of many engineers, when they are starting out, to say that they can do a piece of work for a certain figure, and find that they cannot do any such thing.

Mr. Dulin. The first note that I have from Mr. Warren's statement is, that there was about 15 per cent of moisture in rock and sand.

Mr. W. B. Warren. In rock, sand and screenings.

Mr. Dulin. I will admit that the sand will sometimes run about 15 per cent.

Mr. W. B. Warren. Sand runs about 20 per cent sometimes.

Mr. Dulin. I have noticed in my experience that it will shrink about 15 per cent. That has been taken into account in a number of tabulated statements which I have. I refer to Taylor & Thompson Concrete, p. 181, and Lilletti Cost Data, p. 543.

Mr. W. B. Warren. That is only on shrinkage per yd., and there are other shrinkages which have not been taken into consideration. The combination of shrinkage figures out about 20 per cent.

Mr. Dulin. I think you will find that we have figured out these costs to a considerable extent and that we understand them very clearly. Some of the other losses he speaks about we did not figure in at all, because they depend very much on the personality, and, on the conditions surrounding the work. On docks, where we have standard facilities, the losses would be much less than they would be out on a highway. On a dock you can clean up, but on a highway you would not be able to clean up so well. You have said that there would be losses, and I do not say that there would be no losses; you have said that it is entirely theoretical. The point that we have tried to arrive at is: What percentage would these lack of being practical, and then when we have arrived at what that percentage would be, we have planned to add that percentage and in this way arrive at the cost of doing the work in a practical manner, and at the actual cost. For instance, the cost of asphalt was $10.50 per ton. I thought that

in giving that figure I was being fair. I believe, Mr. Warren, that you admitted the other day that it was $10.30.

Mr. W. B. Warren. Yes, I said $10.30 on the boat, in Portland.

Mr. Dulin. The price of asphalt is very much like the price of cement. It varies considerably. I have had asphalt quoted to me as low as $9.20 per ton.

Now, in regard to using more than 85 lbs. of asphalt, which he mentioned: The 85 lbs. would be the actual box weights. It shows up that way by analysis.

Mr. W. B. Warren. It goes to show, then, that the analysis is not correct. You do not get all of the stuff in the pavement. It does not check up to that extent.

Mr. Dulin. I am figuring the analysis from the samples taken from the wagons immediately after they are dumped. I am sorry if I am off, because I checked with your own chemist in this matter.

Mr. W. B. Warren. The box weight is 95 lbs. that they are using. The actual weight used is that much. They are checked as they are delivered and the scales are checked twice a day to keep them correct.

Mr. Dulin. We have considerable trouble in the city with all pavements on account of the contractors pulling their box weights a little too heavily, and, sometimes 95 lbs. is not enough, because they will over-sand the charge.

I believe that you misunderstand me in regard to the work at Albany. It was not a run of ten days, but extended from Aug. 12th to Oct. 22nd. There was a lot of rainy weather during that time. There were eighteen thousand sq. yds. laid.

Mr. W. B. Warren. I did misunderstand you, I believe.

Mr. John R. Penland, City Engineer of Albany, Oregon. I have been considerably interested in what has just been going on here. I am more interested, perhaps, than most of you. This is due, perhaps, to the fact that during the course of this discussion, some of my own figures have been quoted. I have reference to the figures in connection with the Albany paving. I had supervision of the work down there. I have been interested in noting the items brought out in the discussion which should have been considered in the figures, and which, according to the last speaker, were omitted, and, which, because of that omission, have been

stigmatized as theoretical, and not practical. I will say that I do not remember the exact amount, but it was something like 18,000 sq. yds. The total cost of this 5 inch pavement, with a 3½ inch binder, and an inch and a half top, according to specifications, was $.3703 for the binder and the cost of the top 1½ inches was $.28 or a fraction over that. The total cost, and this includes everything, except the maintenance, or rental of the plant, which is not taken into account, is $.6488. I will state, in passing, that this pavement was laid simply as a test, more than anything else: it was a test to find out what it would cost. This was not a municipal plant. The contract was let for the work, and the price paid was $1.15 and $1.05. The statement was made that it could be laid for $1.00 a yd., and still leave a reasonable profit. In fact, I was extremely anxious myself to get a trial at it at those figures. The bids, as I recall them, were rejected, and bids were accepted for $1.15, and later on, some more was laid for $1.05. The actual cost that showed up as a result of this experiment was less than I expected. This was notwithstanding the fact that my figures, theoretically, were between $.67 and $.68. We beat that.

It was a very good test on this account, that all of the men and all the help engaged on the work were inexperienced, except one man. This was true all the way down in the case of all the men, even to the roller man. It was true in the case of all of the men, for not a single man had had any experience. The paving was laid by the Asphalt Machinery Company of Seattle, and was not laid by a paving company. It was a job that was undertaken by a company, which was in the business of selling plants, and wanted to sell a plant in order to demonstrate to the people of Albany what pavements could be laid for.

As to the correctness of those figures, I might say that it was agreed to before the contract was ever let, that I should have full access to everything in connection with the job, and especially to the bank account and to the bank books and checks, and from all of these sources these figures were obtained. I have also arranged all these figures in tabulated form, so that we are certain that every item is exactly as it was, and not theoretical. We found the difference between the quantities of materials that were paid for and those actually used, and we found that the amount actually used was less than the amount paid for. Of course, I have not figured out the details, but everything is shown in such a shape

in the way that I have compiled the data of all these articles so that you can see exactly what they were, and the total cost was $.6488.

Mr. W. B. Warren. I would like to ask if that included overhead charges and the cost of liability insurance.

Mr. Penland. We included in this the cost of the up-keep of the plant. I do not, however, remember what all the details were. I will say that it does not include, and I have always somewhat criticised the plan of including these things, a lot of overhead expenses, like the cost of promotion, the cost of office help and other things that are carried on the books, nor does it include the cost of legal advice, etc., that are usually taken into account. In many cases, these things are taken into account and tend to increase the total cost.

Mr. Dulin. There are one or two questions that I would like to ask Mr. Warren. You spoke of laying wearing surface down at the rate of 3.9 sq. yds. per batch. Is it not a fact that the work is often done at a rate of 4.4 sq. yds. per batch?

Mr. W. B. Warren. Yes, it runs from 4.7 to 3.9.

Mr. Dulin. Another item that you spoke of is the cost of laying the pavement, and you referred to the difference in cost for laying a 5 inch pavement as against a 2 inch top. In laying the base and the top separately, two spreadings, two rakings and two rollings are necessary. Now the Albany specifications called for two spreadings and two rakings and two rollings, and not merely for one spreading, raking and rolling, required for a two inch wearing surface.

Mr. McMullen. Another thing that you spoke about was the contractor's bonds. The contractor's liability bond is a thing that we did not take into consideration. In a measure, our data is based more or less on a municipal ownership plan.

Mr. W. B. Warren. If there is time, I wish that you could go into another matter, the matter of the up-keep of the road. I would also like to have you go into the matter of the guarantee of the contract.

Mr. McMullen. The facts in regard to the auto trucks and the facts that I gave you in regard to these other matters are all a part of the records of Multnomah County, and are taken from the records of operation with automobile trucks, and on contracts of a like nature. These things are all a matter of record and

they can be had by applying to the County Commissioners for them. In the case of the auto trucks owned by the County and in the case of the material, crushed rock and gravel, the County has obtained these prices on all these things, and, in fact, they have secured prices which are less than those which I have given. All of these things are a matter of public record in the County Court of this County.

Mr. W. B. Warren. Did they figure in everything that should be included? For instance, like the interest on investment and depreciation?

Mr. McMullen. They figured, for instance, in the cost of driving the automobile trucks, the salary of the driver at $3.50 per day, and the cost of the tires per mile at $.05; depreciation, $.04 per mile, and one gallon of lubricating oil per 80 miles. The repairs per day were figured at $2.00, making something like $730 per year. Gasoline was figured as consumed, at the rate of 4 miles to one gallon, and grease at $.10 to $.15 per day; interest was figured at 6 per cent on cost of equipment. The truck should be equal to 250,000 miles with the liberal annual allowance made for repairs and replacement of wearing parts. It was figured that a cost of $.05 per mile would cover the cost of depreciation. This, added to the cost of materials and labor, would make the cost of hauling $.80 per ton for a 10 mile haul.

Mr. W. B. Warren. I would like to say that I think that you could not haul material for $.80 per ton, ten miles with an auto truck.

A Spokane Engineer. The City of Spokane, which has a municipal plant, in order to give all the contractors a chance to bid, has adopted a policy of selling to any contractor bituminous top for pavement, and have Bituminous No. 1 and No. 2 pavement for sale. No. 1 has a three inch surface, and Bituminous No. 2 has a two inch surface. Here is a letter that I have recently received in this city from the City Engineer's Office of Spokane. They give here these various prices, which range from $.40 to $.60 per sq. yd., depending upon the size of the job and the length of the haul. The price is $.75 per sq. yd. in the case of No. 1. Of course, in taking any cost data you must be very careful in the consideration of it, and take into account all of the various items that go in there. The very fact that the City of Spokane is selling asphalt from its plant and is selling a wearing

surface for No. 2 from $.40 to $.60 must be taken into very careful consideration, especially because the conditions there are different from what they are in Portland.

MR. MCMULLEN. You say $.40 to $.60? I would like to ask you how thick that is.

SPOKANE ENGINEER. Two inches thick. The variation in price from $.40 to $.60 means that it varies in accordance with the distance the City has to deliver it.

MR. MCMULLEN. You say that distance is the cause for the variation and ranges of price?

SPOKANE ENGINEER. Yes, sir. Close to the plant it would be $.42, a little further away it would be a little more, then more, etc. The further away it got the more it would cost.

MR. MCMULLEN. Then, I infer that the $.60 rate is the limit of the haul that they have over there. If, say, No. 1 or No. 2 is used, it is $.60, and perhaps less, but no more?

SPOKANE ENGINEER. Yes, sir; but I am not very familiar with the details.

MR. MCMULLEN. Portland, being a seaport and a terminal point for the different railroads, which are engaged in the hauling of bitumen, and, securing a price of from $9.00 to $10.50 per ton, I would like to ask if Spokane gets the same terminal rates on bitumen, or asphaltum, as Portland does. I would like to know if this would not cut some figure. As you know, in Spokane they have been having considerable rate trouble for four or five years.

SPOKANE ENGINEER. I noticed a price there quoted for $10.00 per ton. I noticed that over four years ago, it was $20.00 per ton.

MR. MCMULLEN. It still remains a fact, I believe, if Portland is a point of shipment, freight will have to go from Portland to Spokane, and, in any case, freight will have to be added from Seattle to Spokane on the bitumen.

SPOKANE ENGINEER. Yes, sir.

MR. T. A. GARROW, Engineer, Warren Const. Company. In regard to the Albany work, and in regard to their plant, it has been shown that there was no depreciation allowed on their plant by the Company, for the Company was wishing to sell the plant and brought it there new, and was simply trying to demonstrate the cheapness of their methods of building roads. There was something like $1,000 or $1,500 of freight, getting their plant to

Albany, and there was something like $300 or $400 for dragging the plant out there to the road, and about $205 for setting it up and dissembling the plant. There was bound to be some depreciation on the plant, which was used in that way. I do not think that these items have been taken into consideration, because the prices run up as high as $.15 per sq. yd. for depreciation.

I gather, from an experience covering almost five years, that the average cost of repairs to plant and for reconstruction would be about $.07 per sq. yd. Of course, you know, where we are shipping these plants from place to place this would vary.

Mr. Penland. Of course, there was but one thing in the mind of the president of this Company when he undertook this job, and he simply wanted to bring out one fact, and that was that he had a plant that could be more easily operated and more successfully operated and operated at a lower cost than other plants, and that it was a small plant which could be easily changed from one place to another, and if the haul was more than three-quarters of a mile, it would be money saved to move the plant instead of hauling the material to the plant. With a small plant and a short haul, such as this, we would never use more than three wagons. The capacity is 800 yards of two inch top per day.

Mr. W. B. Warren. I have another question that I would like to ask you. Was this experiment made to see whether the City would buy the plant or not? If so, I think it would be likely that there would be a tendency on the part of the contractor to bear down on the cost of it.

Mr. Penland. I will say in reply to that, that where there are two parties, one of whom wants to sell a plant, and another of whom wants to buy a plant, the man who is going to buy the plant will want to convince himself that the plant is more cheaply operated than any other plant, and that would have been the case with the construction company endeavoring to sell the plant to the people of Albany, but here there was a case where there were not two cities, or two parties. They were endeavoring to ascertain the cost, and to prove that it was such a cost as would warrant the people of the City of Albany in buying the plant.

Mr. Garrow. I would like to ask you yet another question. Was the paper that was issued for this work of par value, or did they discount the City Bonds?

MR. PENLAND. They had to discount the City Bonds. I am not sure how much, but I think it was two or three per cent.

MR. GARROW. Then it would amount to two or three cents per yard from the contractor's standpoint.

MR. PENLAND. Yes, sir; the discount would be a loss to him of from two to three cents per yard.

THE PRESIDENT. Gentlemen, the hour is getting late. I think these results would be very good material for our Journal, and I think that they would be interesting to the City of Portland, and to the City of Albany, or elsewhere.

[NOTE.—Further discussion of this paper is invited, to be received by Joseph W. Peters, 3817 Olive Street, St. Louis, for publication in a subsequent number of the JOURNAL.]

ASSOCIATION
OF
ENGINEERING SOCIETIES
ORGANIZED 1881.

Vol. 55. OCTOBER, 1915. No. 3

ELIMINATION OF THE TOWER GROVE CROSSINGS, ST. LOUIS, MO.

By S. L. WONSON,*
Member of The Engineers' Club of St. Louis.

[Read before the Club, September 29, 1915.]

General Conditions.

The tracks of the Missouri Pacific Railway and the St. Louis & San Francisco (Frisco) Railway lie closely adjacent from the St. Louis Union Station westward nearly to the city limits. For a distance of about two miles, these tracks, with those of several other railways, are located in the Mill Creek Valley, which forms the natural railway entrance to the city from the west, and which is crossed by numerous overhead street bridges and viaducts, the most westerly being at Grand avenue.

Between Grand avenue and Kingshighway boulevard, 1½ miles farther west, the only main thoroughfares for north and south traffic are Tower Grove avenue and Vandeventer avenue (formerly called Old Manchester Road), which intersect at an angle of 52 degrees at the point of crossing of the railways.

*Bridge Engineer, Missouri Pacific Railway Co.

The general location of the railways and streets is shown on the sketch map, Fig. 1. At Tower Grove avenue diverges the Oak Hill Branch of the Missouri Pacific, a double track belt line connecting with the main line of the St. Louis, Iron Mountain & Southern Railway in South St. Louis and used by all St. Louis passenger trains over the Iron Mountain, as

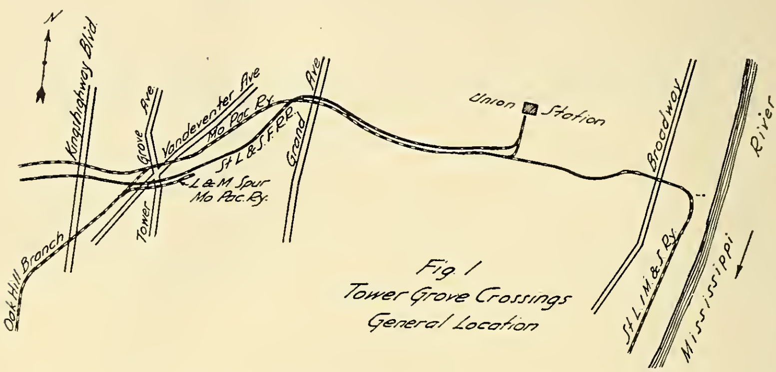


Fig. 1
Tower Grove Crossings
General Location

well as by a considerable industrial switching service. This line crosses the Frisco at grade. Connecting with the Oak Hill Branch, the Missouri Pacific also has a track crossing the streets south of the Frisco tracks and leading into the plant of the Liggett & Myers Tobacco Company, being itself crossed at grade by two Frisco connections to the plant of the American Car Company.

The conditions under which these crossings originated and existed for many years are typical of the development of many grade separation problems arising from railway development and city expansion—first, the early railway construction through an outlying open district; second, the construction of additional tracks and the opening of new streets at grade in a generally level section; third, the increase of street and railway traffic resulting in a busy crossing.

The first track of the Missouri Pacific (then the Pacific Railroad) was built through this section, then outside the city limits, in 1852. Vandeventer avenue existed only as a country road of light travel and Tower Grove avenue was not laid out until many years later. With the development of this section by industries, stores and residences, together with the rapid growth of a large residence territory to the south

served by Tower Grove and Vandeventer avenues as through thoroughfares, the street traffic over the crossings became continually heavier, amounting in 1909 to approximately 400 street cars, 2,400 vehicles and 6,000 pedestrians per 24 hours. Protection by gates and watchmen was afforded for some years prior to elimination.

Both railways maintain passenger stations at Tower Grove, at which practically all passenger trains stop; this, although contributing largely to freedom from serious accidents, increased the inconvenience and delay to street traffic by the necessity of occupying the crossings during stops. The total train movements over the crossings average 250 per 24 hours, of which 100 are passenger trains. The main lines of both railways rise to a natural summit at Tower Grove, while the intersecting streets are practically level, indicating a separation of the crossing, either by street depression as less costly or by track depression as removing the summit in the railway profile. Actually the track depression is limited by considerations of reasonably economical adjustment and practicable operation of important industry connections, as well as by a long ascending grade of the Oak Hill Branch, a short distance to the south.

Previous Plans for Elimination.

The question of eliminating these crossings was first taken up by the city in 1905 on a basis of track depression. After further study, however, by the Board of Public Improvements of the City of St. Louis and the engineering departments of the railways, an agreement was arrived at early in 1907 on the basis of street depression. This plan, shown on Fig. 2, provided for closing Vandeventer avenue across the tracks, connection with Tower Grove avenue being afforded by Hunt avenue on the north and an extension of Blaine avenue on the south. Ordinances embodying this agreement were before the Municipal Assembly without final action until the summer of 1908, when they were definitely rejected, considerable popular opposition having developed to what was called the "tunnel plan."

The Board of Public Improvements, which under the city charter had sole power to originate such measures, was then called upon by the Assembly to send in new ordinances requiring depression of tracks under the existing street levels, but having the benefit of its study of the problem, refrained

from so doing. Such ordinances, however, were otherwise originated and finally approved in April, 1909, requiring an approximate expenditure of $3,000,000 as compared with about $500,000 for street depression. They were considered by the

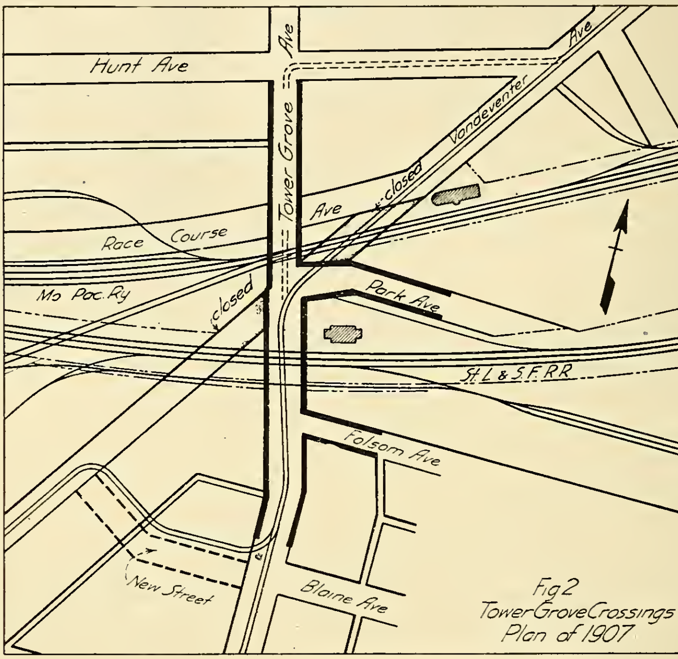


Fig 2
Tower Grove Crossings
Plan of 1907

railways as unduly oppressive and by the industries as destructive of their railway connections and it became necessary to determine the rights of the parties in court.

The ordinances were upheld by the St. Louis Circuit Court and appealed to the Supreme Court of Missouri, which in a unanimous opinion handed down in December, 1912, held in brief that while the city had power to require elimination of the crossings and to prescribe the general method, as by track or street depression, the ordinances in question were void, both as being unreasonably burdensome in their requirements and as not having originated with the Board of Public Improvements as prescribed by the City Charter.

Meantime, the present management of the Missouri Pacific

had assumed charge of the property and after becoming familiar with the Tower Grove situation, directed its engineering department to re-examine the matter with a view to another attempt to work out a plan acceptable to all interests. Accordingly, general plans and estimates were prepared for six different methods of elimination, of which one contemplated partial depression of tracks and elevation of streets, being the general method finally adopted.

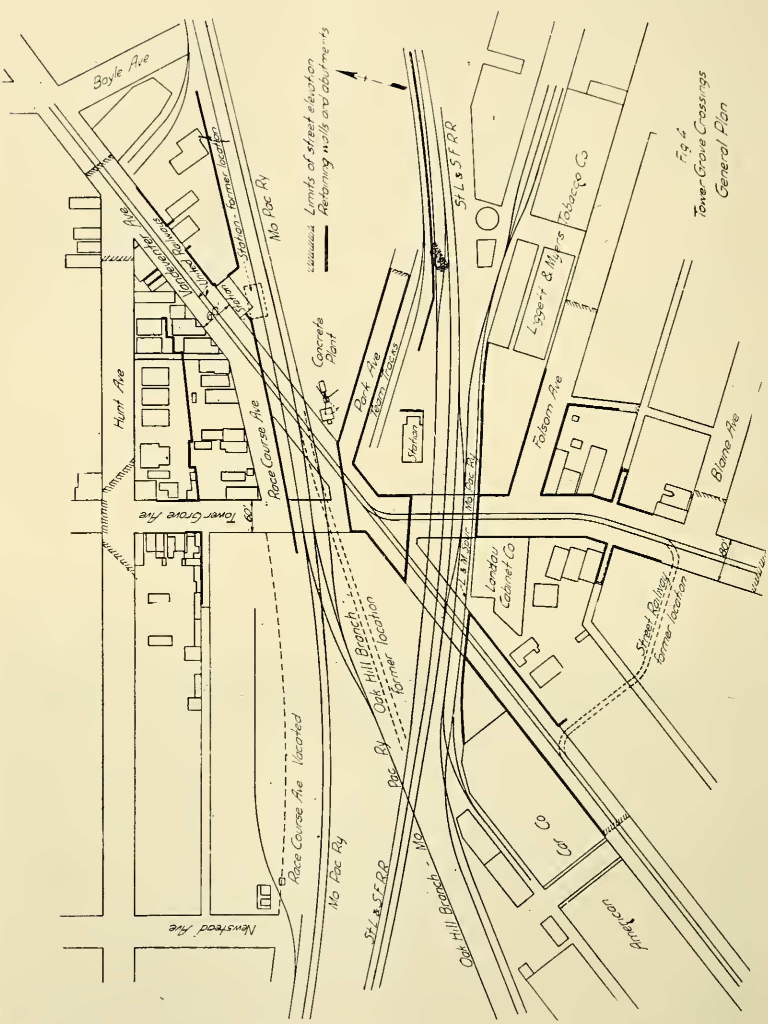
Immediately following the Supreme Court decision of December, 1912, the Board of Public Improvements called a conference with the railways and having its own alternate plans and estimates well under way, announced a preference for partial track depression and street elevation as a basis of elimination. With the active interest and co-operation of all parties, the details were rapidly worked out for a new ordinance, which was passed and approved in March, 1913, and formally accepted by the railways.

Preliminary to preparation of detail plans, a survey party was put in the field and complete maps, profiles and other records were made. Plans of the elimination, prepared by the railways, were thereafter presented to and approved by the Board of Public Improvements and actual work was started on November 1, 1913, ground being broken by His Honor, Henry W. Kiel, Mayor of St. Louis.

Fig. 3. View of crossing from the south before starting elimination work. Nov. 1, 1913.

Adopted Plans.

Fig. 3 shows a photograph of the site (from the south) before starting work. Fig. 4 shows a general plan of the elimination. The streets are elevated 13 feet over the old track elevation on reinforced concrete bridges, and the tracks depressed 13 feet so to afford a 22-foot clearance above top of



rail. The filled street approaches are on 3½ per cent grades with retaining walls along the street lines, except where

abutting property is raised to conformity with the new street grade. On Fig. 4-A are indicated the areas of streets, alleys and private property which have been elevated by earth filling.

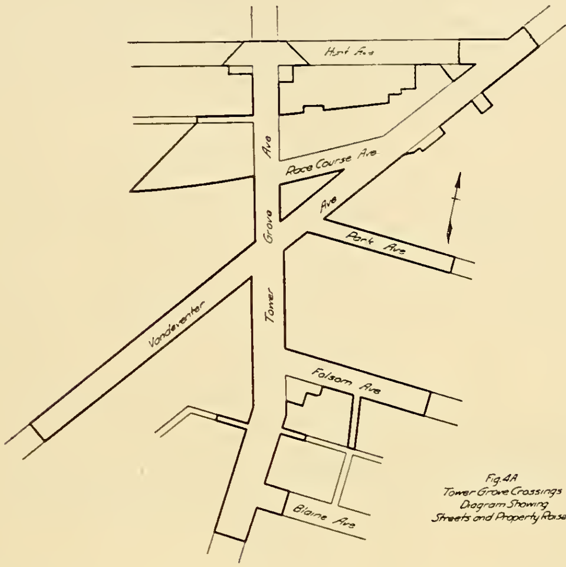


Fig. 4A
Tower Grove Crossings
Diagram Showing
Streets and Property Raised

Realizing that the service level of many lots and buildings, particularly on the north side of the tracks, would in the future undoubtedly be at the new street grade, and that the construction of retaining walls in such cases was an economic waste, the railways endeavored to induce property owners to raise their buildings and lots, offering to provide the necessary filling and pointing out that the expense of restoring the property to the street grade would constitute a definite and easily adjusted claim for damages. Several owners proceeded along these lines, but the majority preferred to await a definite adjustment with the city, which, under the ordinance, assumed the damages. The city officials were successful in making such an adjustment in a number of cases, and under waiver of damages, raised the buildings and built retaining walls at the rear of the lots, the railways providing the filling. Although these negotiations were lengthy and somewhat delayed the progress of the work, the result is thought to be well worth the time and patience expended.

Fig. 5 shows the former and present railway main line profiles with the summit lowered by the depression. The most

unsatisfactory features as to gradient are found on the tracks leading into the plants of the Liggett & Myers Tobacco Company and the American Car Company, shown on Fig. 4, upon which, although depressed as far as practicable into the plants, grades of from 2½ to 3 per cent are required, materially adding to the expense of operating and maintaining the connections.

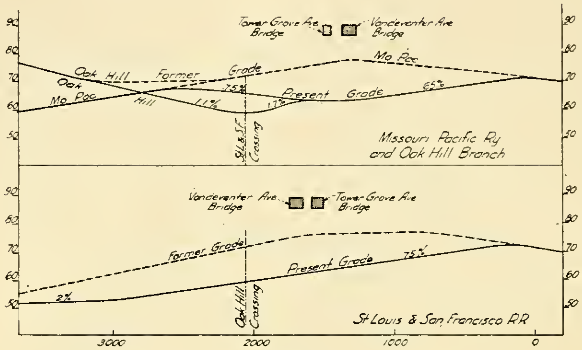


Fig 5
Tower Grove Crossings
Railway Profiles

Fig. 6 is a diagram of the street bridges, which, with their limiting abutments and retaining walls, form an X-shaped

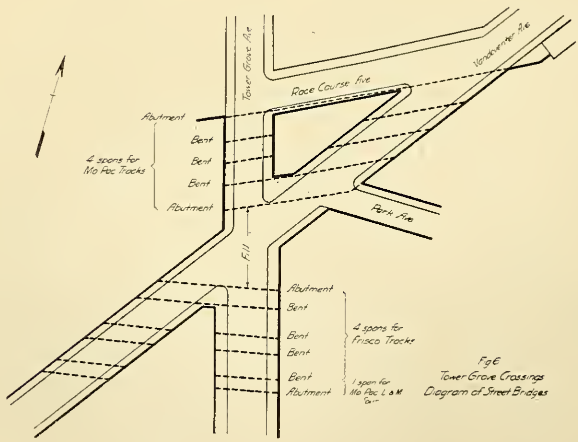


Fig 6
Tower Grove Crossings
Diagram of Street Bridges

structure with a section of solid fill at the central portion between the railways. The construction, except the abutments

of two bridges, is of reinforced concrete throughout, consisting of a beam and slab deck resting on abutments and intermediate bents, and forming four and five spans as shown, planned to fit both present and probable future track requirements. The bents have rectangular columns and footings spaced about 12 feet, center to center. The columns are 18x24 inches and 20x24 inches; they are joined at the tops by cross girders supporting the deck beams and at the feet by continuous diaphragms extending to 4 feet above top of rail, serving primarily as a guard against damage to the bridge from derailed equipments. The footings of bents and abutments are designed for a maximum pressure of 2½ tons per square foot on the firm yellow clay found at this point, which figure was adopted after a series of loading tests had been carried out. Fig. 7 shows a typical elevation and section of the bridges carrying Tower Grove avenue, which makes practically a

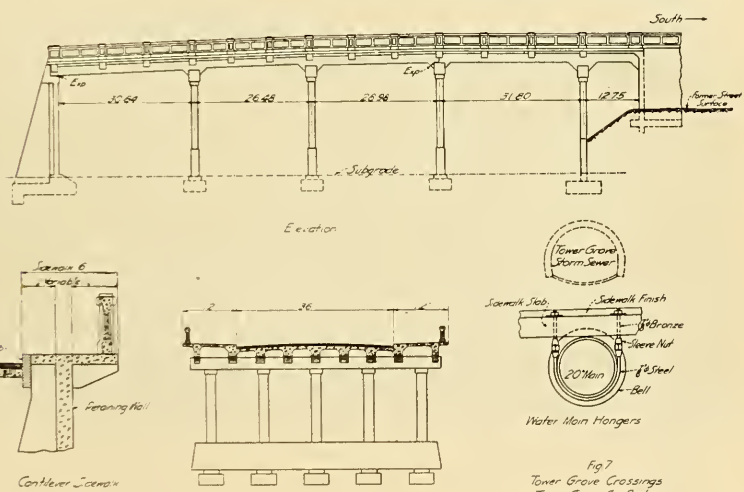


Fig 7
Tower Grove Crossings
Tower Grove Ave Bridge
over Mo Pac Ry

square crossing of the tracks. At the bridges carrying Vandeventer avenue, however, the angle of intersection between street and railway is only about 27 degrees at the Missouri Pacific tracks and 42½ degrees at the Frisco tracks; the deck beams are therefore built normal to the bents and with the deck slab are supported at the street lines by facia girders from 26 to 72 feet long, those over 35 feet being steel plate girders encased in concrete. Fig. 8 shows a typical diagram and sections of the Vandeventer bridges.

The abutments of the Frisco bridges are of gravity section, while for the abutments and connecting retaining walls

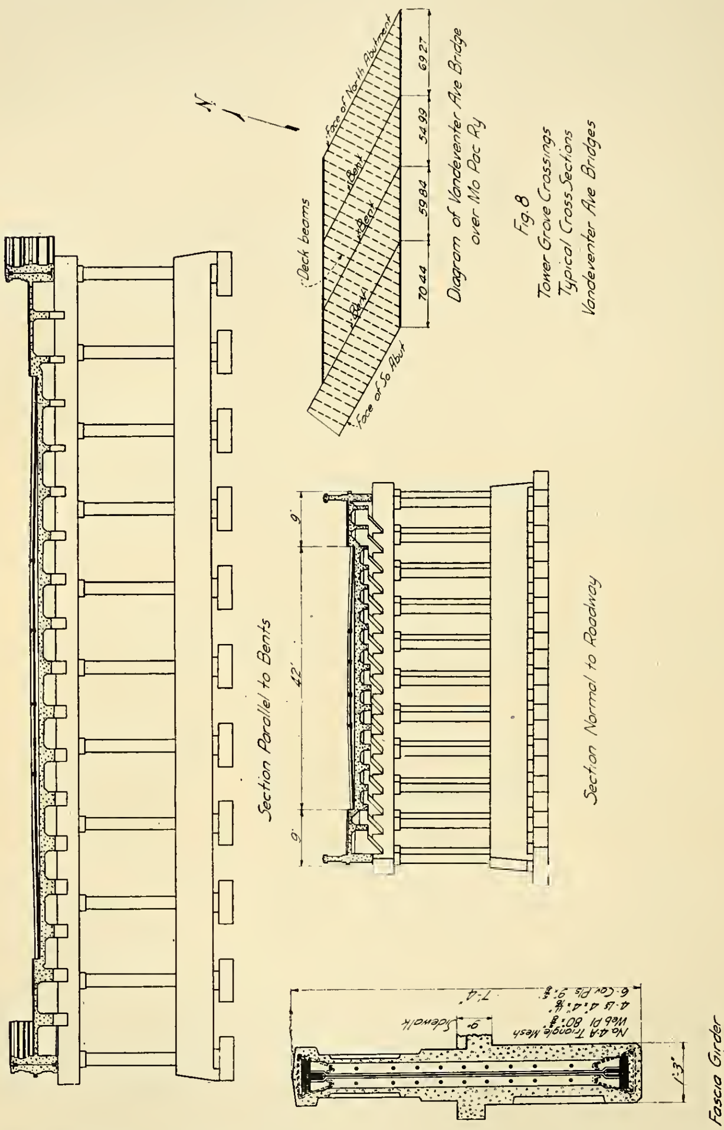
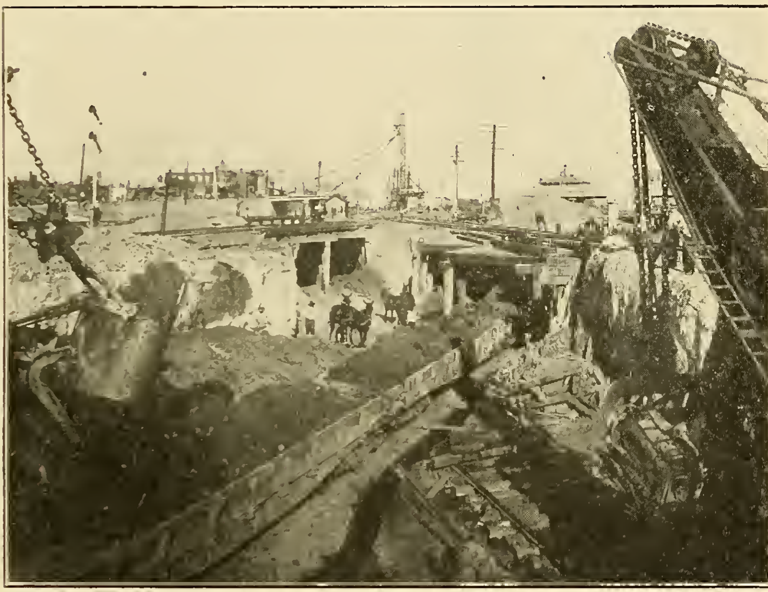


Fig. 8
Tower Grove Crossings
Typical Cross Sections
Vandeventer Ave Bridges

of the Missouri Pacific bridges, a reinforced counterfort type is used on the north side and a bent and slab design on the south side, as indicated in Fig. 7. The Tower Grove storm sewer, built in 1902, passes under this abutment as shown and

after a study of several designs for a satisfactory and not unduly expensive foundation at this point, that indicated, in which the footing pressure is limited to 1½ tons per square feet, was chosen with excellent results.

At Race Course avenue requirements of street width at the elevated level and track room at the depressed grade necessitated the use of cantilever brackets for supporting the sidewalk and concrete rail along the retaining wall between the Tower Grove and Vandeventer bridge abutments. The construction is indicated on Fig. 7 showing the upper por-



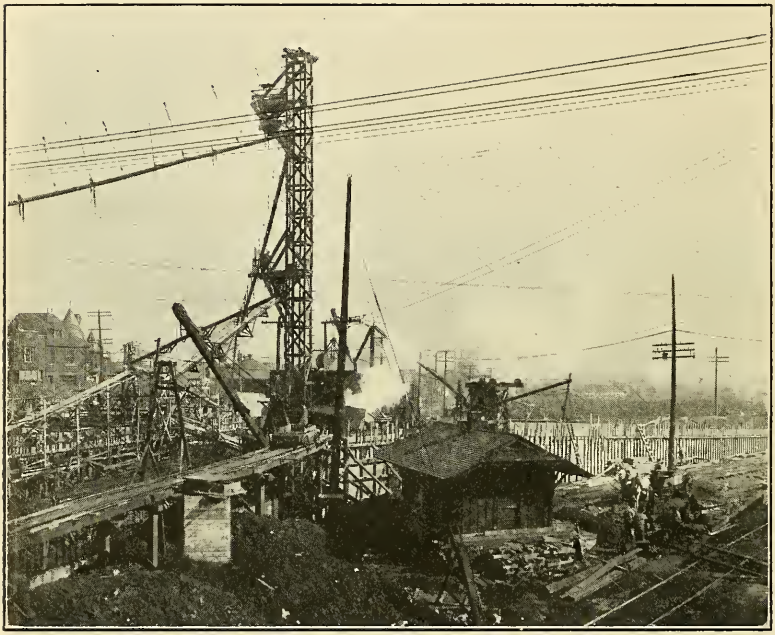
View looking east at crossing of Oak Hill Branch and Frisco Railway, showing excavation and temporary bridges.

tion of the Race Course wall. In order to avoid possible cracking of the sidewalk due to slight settlement of the street fill, the portion of the sidewalk slab inside the wall was also designed as a cantilever. As the face of the retaining wall and the street line are not parallel, the overhang of the sidewalk slab is variable throughout; a feature typifying a considerable absence of uniformity of construction imposed by local conditions throughout the entire work.

With the exception of Park avenue, which is paved with granite blocks, the elimination ordinance required all streets

affected by the work to have creosoted wood block paving on a concrete base, full width concrete sidewalks, steel curbs on the viaducts and granite curbs on the approaches.

A 20-inch water main was supported under the west sidewalk of the Tower Grove Avenue bridges by ⅞-inch round U-hangers 6 feet apart, as shown on Fig. 7. The ends of the hangers embedded in the sidewalk slab are of bronze to insure permanence, and sleeve nuts under the slab permit installation

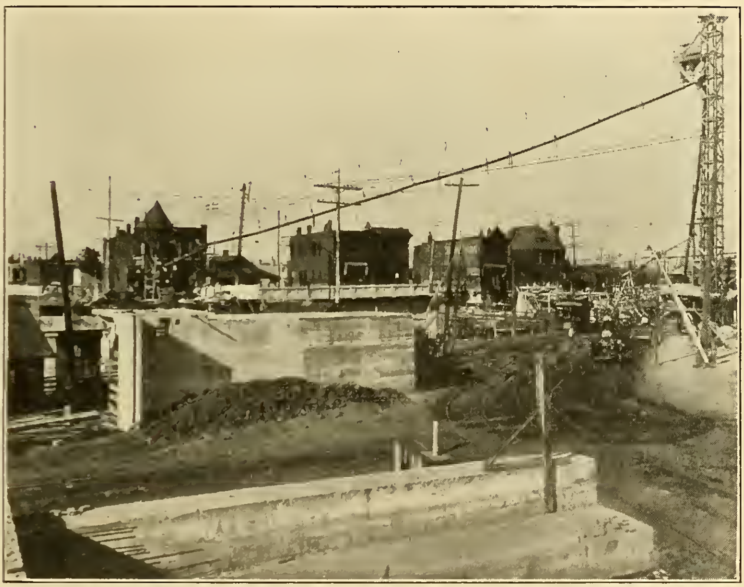


View of tower-plant.

as well as adjustment and replacement of the main. Removable sections of the sidewalk slab provide access to the joints of the main for caulking and repairs by breaking through the 2½-inch sidewalk finish.

Material changes were required in the brick station buildings of each railway. The Missouri Pacific station as indicated in Fig. 4 was formerly located parallel to the tracks and somewhat set back from the street; in order to more fully utilize the station lot owned and to provide room for future additional tracks, it was decided to relocate the building at the new street grade, parallel to and 2 feet from the building line.

New foundations were built in trenches down to the depressed track level and partly under the building, which was kept in service until the new foundation walls were brought up to the former street level. Station service was then temporarily transferred to two large box car bodies fitted up for the purpose, while the building was raised and moved to the new level and location and the foundations completed. In order to provide room for a contemplated future track along the north side of the right of way, it was necessary that the outside platform on the south side should be supported on cantilever brackets outside the foundation walls.



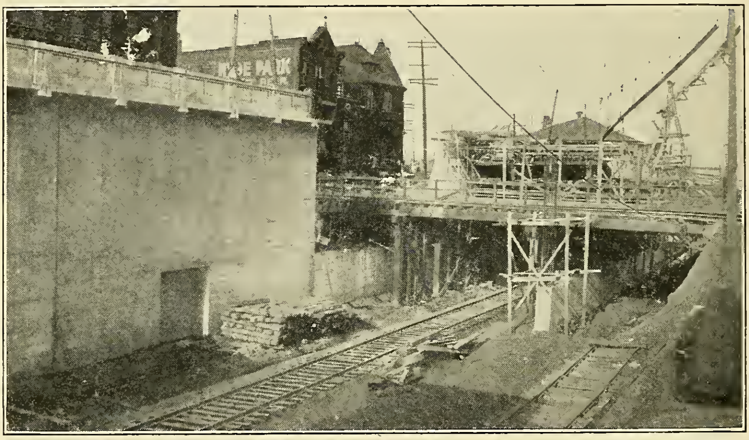
View looking north from street intersection; street traffic on surface level and viaducts partly completed. Oct. 5, 1914.

The Frisco station has been maintained without change in level or position; it was underpinned with new foundation walls to the depressed track level and stairway connections to street and tracks were constructed.

Division of Cost.

The elimination ordinance provided that the construction cost, including the relocation of municipal sewers and water mains, should be assumed by the railways and the damages to

abutting property by the city. The expense of rearranging utilities, other than those municipally owned, such as street car tracks, gas mains, conduits, wires, etc., was assumed by the proprietary interests. No attempt was made to prescribe by ordinance the division of cost between the railways of the work to be performed by them, as it was considered that such division could in this case best be arrived at between the railways themselves. Each, of course, assumed the rearrangement of its own facilities, and prior to starting work, an agreement was reached that each should build the viaducts over



Depression for Missouri Pacific tracks east of Tower Grove ave., showing temporary street bridge at Vandeventer ave.

its own tracks and the approaches thereto; this agreement also provided for a specified division of the work of raising Park avenue and those portions of Tower Grove and Vandeventer avenues between the tracks. There resulted a distinct division of the work on the basis of location except as to the construction by the Missouri Pacific of two spans over its Liggett & Myers spur south of the Frisco tracks and of the retaining walls and building underpinning required by its depression. With the exception of these latter items and of the raising and moving of its station building, the Missouri Pacific handled all work with its own forces. The Frisco performed its track depression and rearrangement with its own forces and the remainder of its work by contract.

Conduct of the Work.

Owing to the considerable volume of street traffic and the absence of other crossings in the vicinity, it was necessary to provide for maintenance of street traffic throughout the construction. Consideration was given to the construction of a temporary highway viaduct at one side of the streets but it was felt that the considerable extra expense involved would not result in material advantage and that traffic could be reasonably handled by one street on each side of the tracks. The city, therefore, permitted closing the two west legs of the X, that is, Tower Grove avenue north and Vandeventer avenue south of the intersection, the plan being to complete elevation of these sections and turn street traffic over them, permitting in turn the closing and elevation of the other two legs of the X. This plan, with minor changes, was followed.

Fig. 9 illustrates the successive steps in making the Missouri Pacific track depression. The two main tracks were first thrown over to the south side of the right of way and a steam

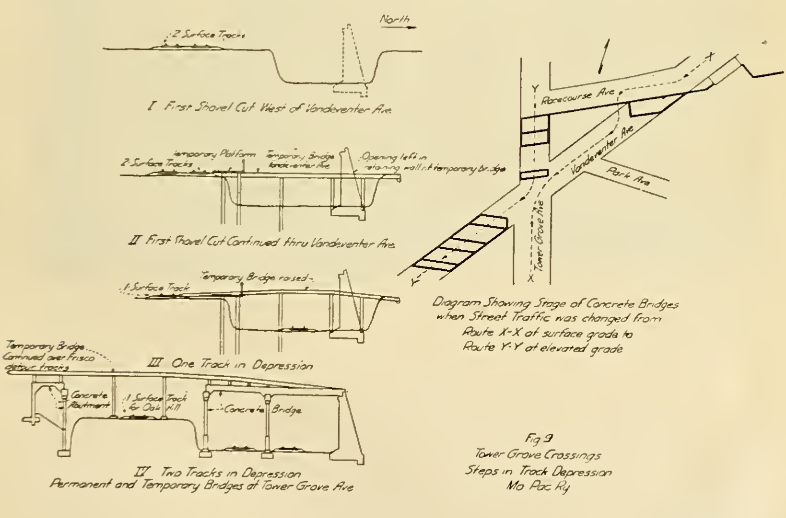
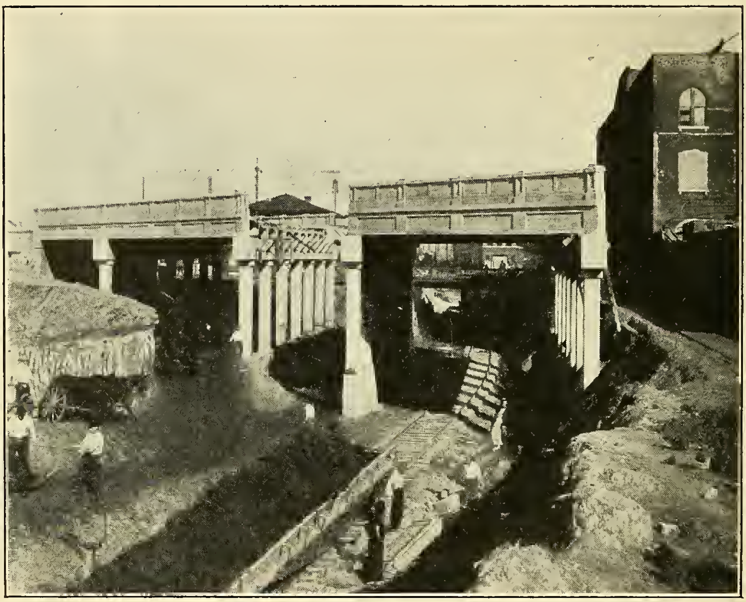


Fig 9
Tower Grove Crossings
Steps in Track Depression
Mo Pac Ry

shovel cut as wide as practicable along the north side was started from the west end of the depression; the shovel being carried on blocking through the deeper portion of the cut to permit loading on cars on a surface track. In the vicinity of the streets the cut was widened to include excavation for the bridge abutments and retaining walls along the north side of

the tracks in order that the concrete work might be started. When the shovel reached Tower Grove avenue, its progress was stopped by a 24-inch gas main and as considerable delay in removing the main appeared probable, the shovel was removed and cut in again at the surface over the main, the excavation behind it being completed by other means. When the cut had been carried up to the street car tracks in Vandeventer avenue, a wooden bridge was built behind the shovel to carry the street traffic over the excavation by a slight de-



Excavation for Frisco tracks; Vandeventer ave. viaduct partially complete: temporary Tower Grove ave. bridge in background. Oct. 5, 1914.

tour. The cut was then continued through the street and to the east end of the depression. East of the streets sufficient width could not be left between the operated surface tracks and the edge of the excavation for the proper accommodation of passengers and handling of baggage, and a temporary platform 500 feet long was built along the tracks for this purpose, connection with the station being provided by a temporary foot bridge over the excavation.

A permanent track was then laid in the excavation to which westbound Missouri Pacific traffic was transferred, the tem-

porary street bridge at Vandeventer avenue being raised about 4 feet to provide overhead clearance. This permitted the removal of one of the two surface tracks, widening the excavation, and construction of the second permanent track at the depressed level. The depression of the Oak Hill Branch was performed in a similar manner, except that for a distance of 1,000 feet from the Frisco crossing south to McRee avenue only one track has been depressed pending a possible relocation at this point.

The greater portion of the material for raising streets and private property was dumped from the dirt trains brought on a temporary track from the west end of the depression into Tower Grove, Race Course and Vandeventer avenues. A con-

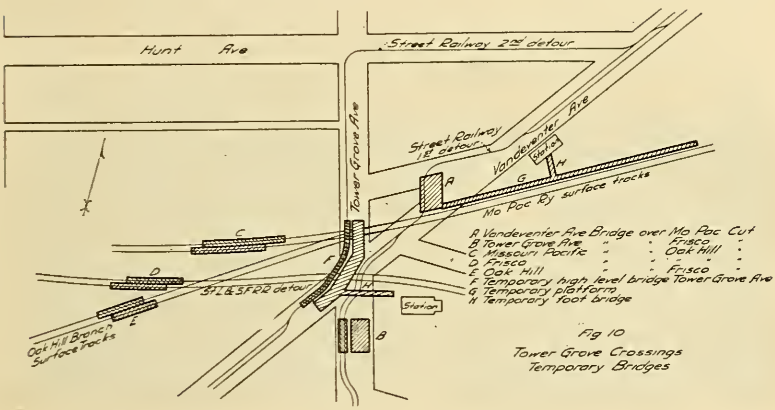


Fig 10
Tower Grove Crossings
Temporary Bridges

siderable amount was also deposited directly on the ground by the steam shovel when working near the streets and spread by teams. The balance of the excavation not required for filling was disposed of at near-by points on the line.

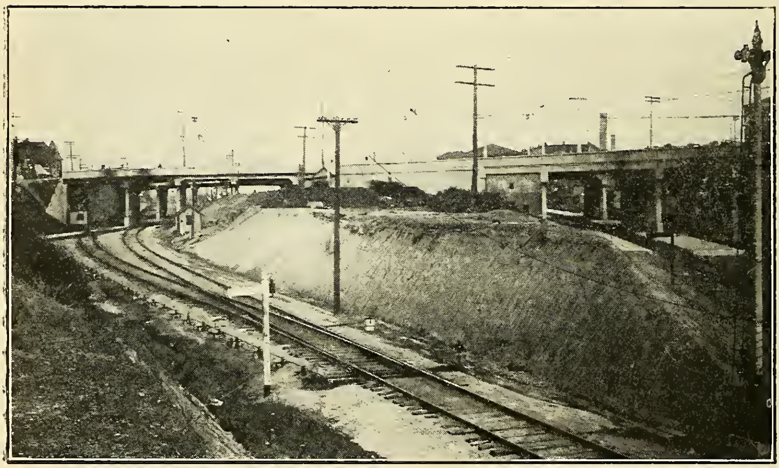
The Frisco excavation was also made by steam shovel under somewhat less difficult operating conditions as it was here possible to divert traffic on two temporary tracks largely clear of the excavated area. A portion of the cutting beneath and between the street bridges was handled very successfully by a Thew shovel, loading on cars or into teams as conditions dictated.

Fig. 9 also shows the stage of viaduct construction on December 1, 1914, when street traffic was transferred from the natural surface over the two east legs of the X to the high level

over the two west legs, the gaps in the permanent work being closed by temporary wooden bridges. Prior to this change, as shown on Fig. 10, temporary bridges were in service for

Vandeventer Ave.	traffic	over	the	Missouri Pacific	cut
Tower Grove "	"	"	"	Frisco	"
Missouri Pacific	"	"	"	Oak Hill	"
Frisco	"	"	"	Oak Hill	"
Oak Hill	"	"	"	Frisco	"

It had been intended to change all railway traffic to the depressed level and the highway traffic to the elevated level



General view of viaducts from the west.

on the same day, but unforeseen delays and complications made it impossible to abandon all the surface tracks at this time. A temporary bridge ("F" on Fig. 10) was therefore built to carry street traffic over the incomplete portion of Tower Grove avenue north and Vandeventer avenue south of the street intersection. To provide for clearance over the surface track used by Oak Hill trains and the Frisco detour tracks, this bridge was raised about 4 feet above the permanent street grade with runoffs on the completed concrete viaducts. After this change in street traffic, a comparatively free opportunity was afforded for the remaining steps of the work. All railway traffic was removed from the surface in February, 1915, and on July 31 all streets were opened for travel.

For handling concrete the Missouri Pacific installed a tower plant with chutes at the corner of Park and Vandeventer avenues, served by a temporary spur track. The location is

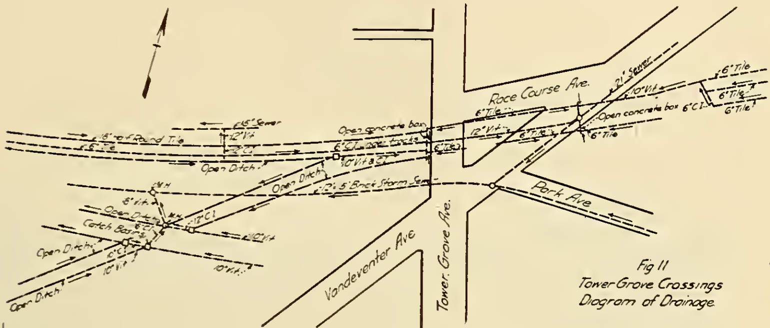


Fig 11
Tower Grove Crossings
Diagram of Drainage

shown on Fig. 4. Sand and gravel were unloaded by a derrick and clam shell bucket into a divided bin and drawn by gravity into a divided truck which was moved to the mixer and

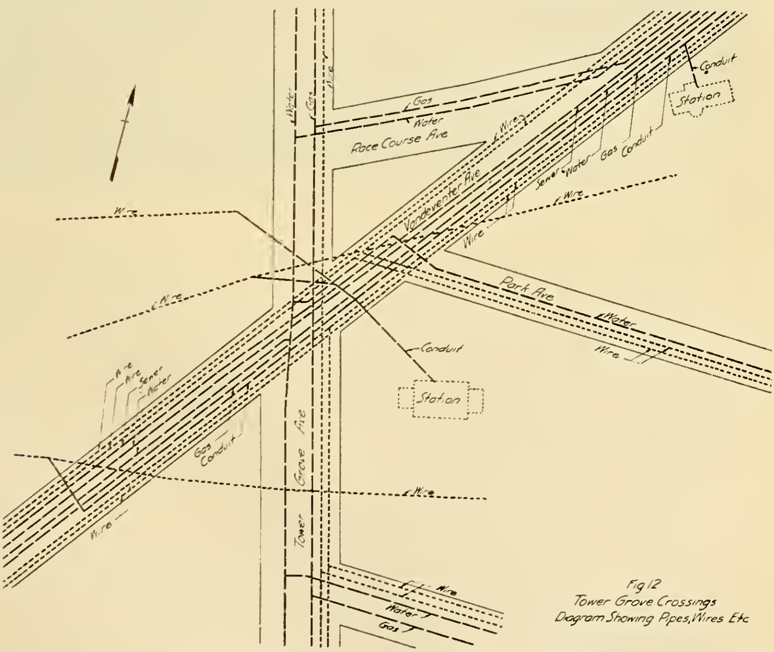


Fig 12
Tower Grove Crossings
Diagram Showing Pipes, Wires Etc

dumped into the hopper by a cable attached to the hoisting engine.

On the Frisco work a small portable tower traveling with

the mixer was used and the material was handled to it in wagons from the team tracks at Park avenue.

Ample provision for draining the depressed tracks was necessary, particularly in the case of the Missouri Pacific and Oak Hill, which rise in each direction from the depression. This is afforded by the Tower Grove storm sewer, which lies about 10 feet below the depression, and by a 21-inch sewer in Vandeventer avenue, lowered to pass under the tracks and discharging into the storm sewer. Fig. 11 is a diagram of the longitudinal and cross drains built in the depression which successfully disposed of extraordinary rainfalls in the past few months.

Fig. 12 is a diagram showing the underground pipes and the groups of overhead wires exclusive of the street railway's overhead work, all of which had to be rearranged during the work. The city at one time contemplated prohibition of all overhead wires over the viaducts and approaches except trolley wires, but this was concluded to be a severe burden on the wire using companies at this time and use was therefore permitted, under suitable terms, of concrete poles erected by the city.

Volume of Work.

The following are the more important items involved in the construction work:

220,000	cu. yds. excavation
60,000	cu. yds. filling
9,500	cu. yds. plain concrete
7,900	cu. yds. reinforced concrete
540	tons reinforcing steel
78	tons structural steel
23,300	sq. yds. paving
7,200	lin. ft. curbing
68,500	sq. ft. sidewalk
1,840	lin. ft. concrete hand rail
3,400	lin. ft. gas pipe hand rail
25	permanent buildings raised or underpinned
10½	miles track lowered or relocated

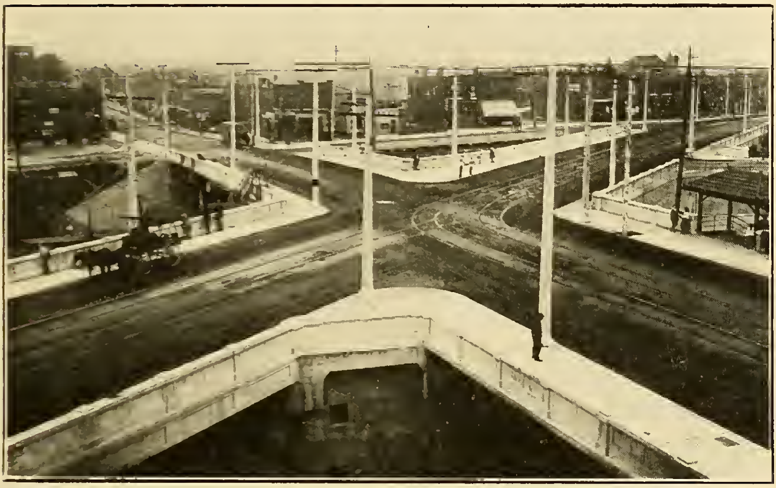
The total cost to the railways, the city and the public utility companies is $830,000.

Owing to the conditions imposed upon both design and construction, the work required attention out of proportion to

its magnitude. More than 200 drawings covering the permanent work as constructed were prepared by the Missouri Pacific alone, including, however, the detail plans of all the reinforced concrete bridges.

Engineers.

The engineers in charge of the planning and execution of the work were, for the city: E. R. Kinsey, President, Board



View of crossing from the south after completion of viaducts.

of Public Service (formerly Board of Public Improvements); C. M. Talbert, Director of Streets and Sewers, and L. R. Bowen, Bridge Engineer. For the St. Louis & San Francisco R. R.: F. G. Jonah, Chief Engineer, and Perry Topping, Assistant Engineer, who also acted as resident engineer. For the Missouri Pacific Railway: C. E. Smith, formerly Assistant Chief Engineer, during the later stage of construction; E. A. Hadley, Chief Engineer, and the writer, ably assisted by W. D. Hudson, L. H. Davis and S. M. Bates, Assistant Engineers, the latter being resident engineer in charge.

Acknowledgement is also made of the cordial co-operation of the local operating officials of both railways whose assistance was of great importance in carrying out the work without interruption of traffic.

[NOTE.—Further discussion of this paper is invited, to be received by Joseph W. Peters, 3817 Olive Street, St. Louis, for publication in a subsequent number of the JOURNAL.]

THE ADJUSTMENT OF THE CONSEQUENTIAL DAMAGES AT THE TOWER GROVE CROSSINGS.

By L. R. Bowen,*
Member of The Engineers' Club of St. Louis.

[Read before the Club, September 29, 1915.]

In the ordinance providing for the elimination of the grade crossings at Tower Grove the City of St. Louis bound itself, in consideration of the acceptance of the ordinance by the Missouri Pacific and the St. Louis and San Francisco Railway Companies, to adjust and pay all damages caused by the changes in the grades of the streets and alleys, as provided in the ordinance, that might accrue to property fronting or abutting on streets and alleys where the grade should be changed excepting property owned by, leased to or in possession of said railway companies.

The railway companies were required to assume all damages to property owned, leased or possessed by them. Neither the railway companies nor the city is liable for damages caused to industries by reason of the change in grade of the railroad tracks.

Prior to 1875 the city was not liable for damages caused by changes in the street grades, but in that year the word "damaged" was added to Article II, Section 21, of the Missouri State Constitution, so that it now reads: "That private property shall not be taken or *damaged* for public use without just compensation."

It has been established by court decisions that the measure of damages to property, the value of which has been depreciated by a change in the grade of a street in front of it, is either the difference in the fair market value of the property before and just after the change in grade was made, or it is the amount that would have to be expended to adjust the property to the new grade of the street so that it would have the same relative position with reference to the new grade that it had with reference to the old grade. The city is entitled to have the damages determined by the method that it can prove will show the least damage.

*Bridge Engineer, City of St. Louis.

For those who may not be familiar with the methods practiced under the old charter for determining the amount of damages caused by a change in the grade of streets or on account of other public work they will be briefly recited here.

Before any damages could be determined or paid by the city a suit had to be brought and judgment rendered by court. Evidence in damage cases are heard either by court direct, by a jury or by commissioners. Court does not usually hear a case directly and does so only upon request by the parties to the suit. Important cases where the amounts involved are very large or where the issues are quite complex the parties will request commissioners, usually three, which are appointed by the court, one of which commissioners is nominated by the plaintiff and one by the defendant. When either party to a suit insists upon it the evidence is heard by a jury, which fixes the amount of the award.

The usual procedure is this: Each of the parties to the suit engages a number of real estate experts, anywhere from two to six, as the importance of the case may justify. These men inspect the property for their employers and give expert testimony before the jury or commission as to the amount of damages the property has sustained. They charge from $25 to $100 each for their services, depending upon the importance of the case and other considerations. Ofter their opinions vary considerably. In the case of the American Car Company against the City of St. Louis the opinions of the real estate experts as to the depreciation in the market value of the real estate of that company, on account of the change in the grade of Vandeventer avenue, varied, from $14,785 to $276,000. If a jury is deciding the case they are not given an opportunity to view the property and must decide the amount of damages from the evidence heard and remembered.

When work started at Tower Grove it was appreciated that the damages would be heavy, as the streets had been long established and the property was closely built up, especially along and north of Race Course avenue.

Methods of adjusting the damages with a minimum of cost to the city and with the least burden and inconvenience to the property owners were discussed. It was recommended by the Board of Public Service and the City Counsellor that the

city raise and adjust the properties to the new street grades wherever it could make fair terms with the owners. While this method seemed very practical and desirable, no legal way of doing it seemed apparent and besides city officials were quite reluctant to undertake so unusual a procedure in view of the very harsh criticism that would result should any mistakes in judgment be made.

After a conference between the Mayor, Comptroller, Board of Public Improvements and the City Counsellor, however, the City Counsellor ruled that the necessity for this work to be done by the city was very urgent and that an emergency therefore existed within the meaning of the Charter and the City Bridge Department was authorized to proceed with the work if fair terms could be made with the property owners. The Comptroller stipulated, however, that only those pieces of property situated on the north side of Race Course avenue between Vandeventer avenue and Tower Grove avenue and on the west side of Vandeventer avenue between Race Course avenue and Hunt avenue should be raised and adjusted by the city. The method of procedure was this: Plans and specifications were made for raising each parcel of land and the improvements thereon and when the work to be done had been agreed upon by those having an interest in the property a waiver of damages was drawn up with the provision that it would become effective upon the completion of the work agreed upon, which was very carefully set out, and the payment to the owner or lessee of the normal rent upon the property for the period during which it would be untenable. When these agreements were properly signed by all parties having an interest in the property and by the City Counsellor and the Comptroller, the actual work was begun.

The work was started with the regular funds of the Bridge Department, but when it became necessary to secure a definite appropriation for carrying on the work very serious opposition was raised by certain house raisers and others having personal interests affected by the work. However, the necessary appropriation was secured.

Much of the work of preparing the plans and all of the actual work of raising the buildings was done under the direction of Mr. W. R. Crecelius, of the City Bridge Department.

The city raised eight separate parcels of land with the improvements thereon, consisting of nine brick houses and three frame houses and a number of sheds and stables. Those along Race Course avenue were raised distances varying from 8 to 12½ feet. Those along Vandeventer avenue from 2½ to 11½ feet.

The Missouri Pacific Railway Company furnished and placed all dirt required for filling the lots, amounting to about 16,000 cubic yards.

The cost of raising the buildings at Tower Grove was $28,992.46; $5,054.18 in rents and refund of licenses was paid on the buildings for the periods when they were untenable. The house raising equipment cost $1,902.07, most of which is in good condition and available for other work of the Bridge Department.

Of other damages at Tower Grove seven cases have been settled in court and the awards paid, one case has been appealed by the city and there are three cases still pending.

Of the seven cases settled in court the amounts of the awards of four of them were agreed upon by the city and the property owners on the basis of estimates prepared by the Bridge Department of the cost of adjusting the properties to the new grades and the loss of rent during the period of reconstruction. There have been four contested suits at Tower Grove.

Following is a list of the damages paid at Tower Grove and the method of settlement:

Damages at Tower Grove Crossing.

Property Adjusted by the City

Name of Owner		
Michael Noe—		
Cost of Construction		$ 1,238.88
Lizzie C. Lorch—		
Cost of Construction	$ 3,864.27	
Rent	673.75	$ 4,538.02
Jas. McElevey—		
Cost of Construction	$ 3,199.65	
Rent	492.50	$ 3,692.15
Joseph Bachle—		
Cost of Construction	$ 3,874.83	
Rent	578.33	$ 4,453.16
Henry Muselman—		
Cost of Construction	$ 4,202.18	
Rent	1,330.60	$ 5,532.78
Mable D. McCully—		
Cost of Construction	$ 7,232.17	
Rent	1,300.00	$ 8,532.17
James Carroll—		
Cost of Construction	$ 2,773.72	
Rent	132.00	$ 2,905.72
George J. Kaime—		
Cost of Construction	$ 2,606.76	
Rent	547.00	$ 3,153.76
TOTAL		$34,046.64

Awarded by Court Upon Agreed Estimates

Wm. Fahrenhorst—		
Amount of Award	$ 3,222.00	
Court Costs	12.20	$ 3,234.20
Geo. Bogie—		
Amount of Award	$ 4,560.00	
Commissioners and Experts	100.00	
Court Costs	12.10	$ 4,672.10
Gustave Hanssen—		
Amount of Award	$ 2,044.00	
Commissioners and Experts	100.00	
Court Costs	24.15	$ 2,168.15
Mary A. Gutke—		
Amount of Award	$ 3,957.28	
Court Costs	11.40	$ 3,968.68
TOTAL		$14,043.13

Awarded by Court Upon Findings of Commissioners

Ethelyn M. Humphreys—		
Award by Commissioners	$ 1,700.00	
Commissioners and Experts	85.00	
Court Costs	48.15	$ 1,833.15
Landau Cabinet Co.—		
Award by Commissioners	$30,000.00	
Commissioners and Experts	1,099.15	
Court Costs	74.55	$31,173.70
Wm. G. Wrisberg—		
Award by Commissioners	$ 8,796.47	
Commissioners and Experts	355.00	
Court Costs	20.45	$ 9,171.92
TOTAL		$42,178.77
American Car Co.—		
Award by Commissioners Appealed by City of St. Louis	$65,000.00	
Commissioners and Experts	910.00	$65,910.00

Suits Pending

	Damages Asked
Chas. and Lizzie Lorch	$12,000.00
Joseph F. Brown	2,000.00
Roy Fairchild	2,500.00
TOTAL	$16,500.00

If we assume that the city will be compelled to pay the award of the commissioners in the case of the American Car Company and one-half of the amount sued for the three cases still pending it will have paid in damages at the Tower Grove Crossing the total sum of $164,428.54.

[NOTE.—Further discussion of this paper is invited, to be received by Joseph W. Peters, 3817 Olive Street, St. Louis, for publication in a subsequent number of the JOURNAL.]

SPHERICAL BEARINGS VERSUS FLAT PLATES IN CRUSHING TESTS ON BRICKS.*

By E. L. Baker and Alex. F. Suss.

It is the opinion of the investigators that there is an error introduced in the omission of a spherical bearing in compression tests of bricks. Although the error introduced by the omission of a spherical bearing may not be great enough to be of any practical significance, it is true that the theoretical crushing strength can only be obtained by the use of some device which will take care of non-parallelism of the compressive surfaces, thereby preventing the development of internal stresses in the specimen and the spalling-off of the specimen on one side.

It is the aim of the investigators to prove by these tests that the crushing strength of bricks is greater as obtained by the use of some type of spherical bearing than by the use of flat plates. In the first one hundred and seventy-three tests we have determined this difference by using flat plates and the one-piece spherical bearing. In order to have relative values we first made the ordinary cross-breaking tests, thus obtaining two halves of the same brick to be used in crushing.

One-half of the brick was crushed with the one-piece spherical bearing and the other half with the plate bearing. It is obvious from an inspection of paving bricks that no two bricks are alike. They are not homogeneous, they are not burned to the same degree of hardness, and their surfaces have different degrees of non-parallelism. Therefore, by using the two halves of the same specimen as described, we have obtained comparative values showing the difference between results as obtained by the use of the one-piece spherical bearing and flat plates.

The reader may be impressed by the wide variation in the result of these tests. The only explanation we can give for such variations is that already given, differences of homogeneity and burning. Arch bricks will necessarily be overburned, while those of the interior of the kiln may be underburned. In ordering the bricks for these tests we called for 2¼ in. by 4 in. by 8 in. vitrified

*A thesis for the degree of B.S. in C.E. at Washington University, published in accordance with Sec. 9 of the Agreement of The Engineers' Club of St. Louis with Student Technical Societies in Missouri.

paving bricks to be taken at random from any part of the kiln, thereby obtaining a sample of brick which would ordinarily be sent out on a job.

The machine used was a Riehlé Brothers, two-hundred-thousand-pound, two-screw machine. The poise was run by hand. The cross-breaking test was made according to the method given in Johnson's "Materials of Construction." The brick was set edgewise on two rounded, knife-edge bearings placed six inches center to center and loaded in the middle. The modulus of rupture was found by applying the formula

$$f = \frac{3\ W\ l}{a\ b\ h^2}$$

where

f = modulus of rupture in pounds per square inch.
W = ultimate load in pounds.
l = distance between knife edges in inches.
b = width of brick in inches.
h = height of brick in inches.

In order to have an approximately uniform cross-section for the crushing tests, it was necessary to surface the bricks after cross-breaking them. This was accomplished by chipping the surfaces with a cold-chisel and hammer. During the surfacing the specimen was kept on a wooden block and the hammer-blows were made as light as possible to be effective in order that the brick would suffer no injury.

The bricks were then calibrated. Six measurements were made on each dimension of the bricks in order to obtain a true average dimension. The halves were then tested with the one-piece spherical bearing and flat plates. Two smoothly surfaced plates, 10 in. by 10 in. by ½ in., were used, one placed on the base of the machine, upon which the specimen was centered, the other resting upon the specimen. The one-piece spherical bearing is of cast steel, one surface of which is flat and the other spherical, having a radius of approximately 10 inches. The spherical surface rested on a flat plate on the base of the machine, the brick was centered on the flat surface of the bearing, and another flat plate was placed between the specimen and the head of the machine. The machine was run at low speed during the tests in order to secure a slow and uniform increase in load. The majority of the specimens failed all at once with a loud report, only á few spalling off and crushing without an increase in load. The

crushing strength per square inch was computed by dividing the total load by the cross-sectional area of the brick.

A table has been prepared showing the results of these tests which will be furnished by the authors to any investigators who wish to use them in any further studies along these lines. In

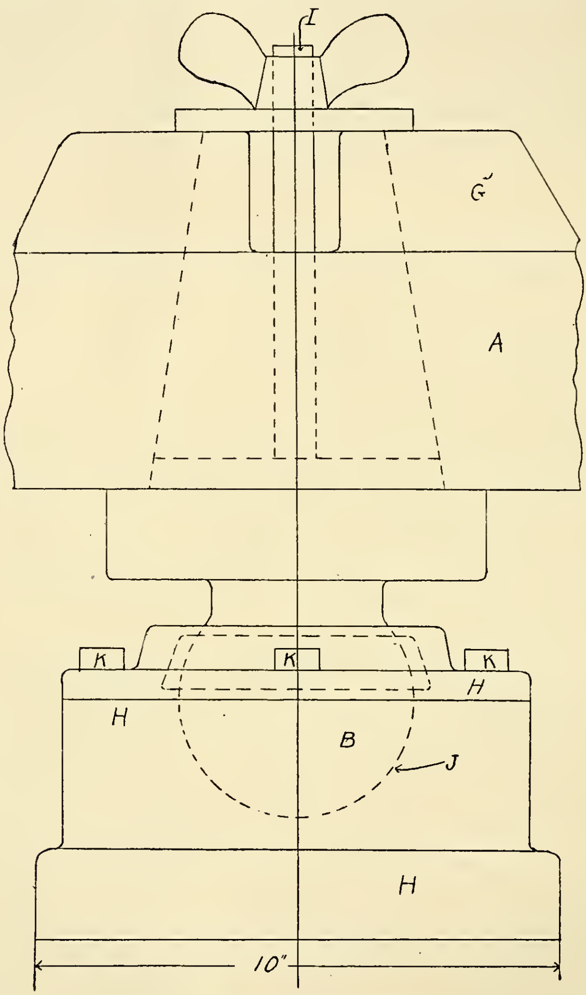


Fig. 1-A. Ball-and-Socket Bearing.

these tables are shown the modulus of rupture, crushing strength between plates, crushing strength with one-piece spherical, and the ratio of the crushing strength as obtained with the spherical bearing to that obtained with the flat plates.

One hundred and forty-seven tests were made with the one-piece spherical bearing and a ball-and-socket bearing made by Riehlé Brothers of Philadelphia, and shown in Figs. 1-a and 1-b. F is a cast-iron cup which rests upon the base of the machine; D is a flat steel plate 10 inches in diameter, the underside of

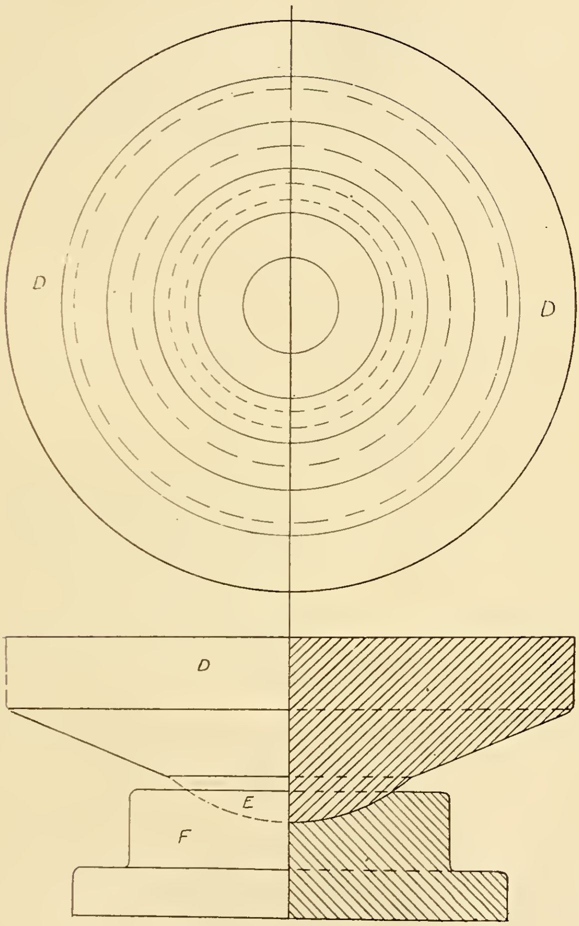


Fig. 1-B. Ball-and-Socket Bearing.

which, E, is semi-spherical and rests in the cup F. Before placing this bearing in the machine, the surfaces of E and F, which are in contact, were thoroughly lubricated with hard-oil in order that they would slide upon each other as freely as possible, thereby eliminating the friction between these surfaces. Parts A, B,

G and H form the unit which is held in the head of the machine by the bolt, I, and thumbscrew. B and A are one solid casting, B being milled perfectly spherical to fit into a semi-spherical socket, J. The casting, H, is in two parts as shown and is held in position by four screws, K. The ball, B, and socket, J, were kept well lubricated with hard-oil. The advantage of this bearing is that there can be no flexure in the specimen regardless of how non-parallel the compressive surfaces may be.

The specimens used in these tests were cross-broken and calibrated in the same way as the specimens in the previous tests.

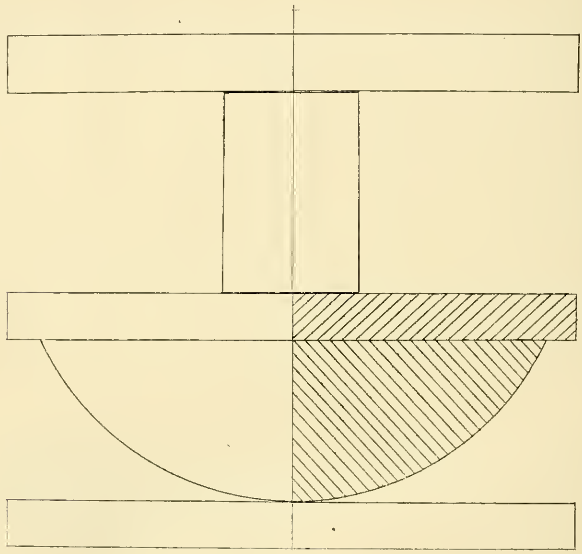


Fig. 2. One-piece Spherical Bearing.

In order to make an intelligent study of the advantages of the spherical bearing, it is necessary to compare the values obtained by testing the two halves of each individual brick. In each case in the first one-hundred and seventy-three tests we divided the spherical test value by the plate test value and set up a ratio for each brick. The average of these ratios should substantiate the theoretical advantages of the spherical bearing if enough tests are made to eliminate differences in material and accidental errors in testing. In the remaining tests the ratio was obtained by dividing the crushing value obtained from the test with the ball-

and-socket bearing by that obtained from the test with the one-piece spherical bearing.

In obtaining points for a curve showing the relation between the unit crushing strength and the ratio of height to least dimension we found the average crushing strength of all the specimens having the same ratio.

RESULTS OF TESTS.

1. The average ratio for the tests made with the one-piece spherical bearing and flat plates is 1.03.

35% of the tests were within 10% of the average ratio.
22% " " " " between 10% and 20% of the average ratio.
16% " " " " " 20% and 30% " " " "
8% " " " " " 30% and 40% " " " "
8% " " " " " 40% and 50% " " " "
11% " " " " not within 50% " " " "

2. The average ratio for the tests made with the ball-and-socket bearing and the one-piece spherical bearing is 1.12.

12% of the tests were within 10% of the average ratio.
30% " " " " between 10% and 20% of the average ratio.
17% " " " " " 20% and 30% " " " "
18% " " " " " 30% and 40% " " " "
9% " " " " " 40% and 50% " " " "
14% " " " " not within 50% " " " "

3. Average unit crushing strength obtained from the plate tests is 8,340 pounds per square inch. The average unit crushing strength obtained from the one-piece spherical bearing tests on the remaining halves of the same bricks used in the flat plate tests is 8,380 pounds per square inch.

A. Flat plate tests:

35% of the tests were within 10% of average crushing strength.
20% " " " " between 10% and 20% of average crushing str'th.
18% " " " " " 20% and 30% " " " "
18% " " " " " 30% and 40% " " " "
5% " " " " " 40% and 50% " " " "
4% " " " " not within 50% " " " "

B. One-piece spherical bearing tests:

9% of the tests were within 10% of average crushing strength.
25% " " " " between 10% and 20% of average crushing str'th.
21% " " " " " 20% and 30% " " " "
21% " " " " " 30% and 40% " " " "
16% " " " " " 40% and 50% " " " "
8% " " " " not within 50% " " " "

4. The average unit crushing strength obtained from the ball-and-socket tests is 9,340 pounds per square inch. The average unit crushing strength obtained from the one-piece spherical

bearing tests on the remaining halves of the bricks used in the ball-and-socket tests is 8,760 pounds per square inch.

A. Ball-and-socket tests:

26%	of the tests were within	10% of average crushing strength.						
19%	" " " "	between 10%	and 20%	of average crushing str'th.				
20%	" " " "	"	20% and 30%	"	"	"	"	
14%	" " " "	"	30% and 40%	"	"	"	"	
10%	" " " "	"	40% and 50%	"	"	"	"	
11%	" " " "	not within	50%	"	"	"	"	

B. One-piece spherical tests:

31%	of the tests were within	10% of average crushing strength.						
26%	of the tests were within	10% of average crushing strength.						
31%	" " " "	between 10%	and 20%	of average crushing str'th.				
15%	" " " "	"	20% and 30%	"	"	"	"	
13%	" " " "	"	30% and 40%	"	"	"	"	
5%	" " " "	"	40% and 50%	"	"	"	"	
5%	" " " "	not within	50%	"	"	"	"	

CONCLUSIONS.

1. The fact that the ratio, 1.03, was obtained from the comparative tests with the one-piece spherical bearing and flat plates, shows that the one-piece bearing has an advantage over the flat plates.

2. The ratio, 1.12, obtained from the tests with the ball-and-socket and one-piece spherical bearing shows that the ball-and-socket bearing has an advantage over the one-piece bearing.

3. We recommend for an average crushing value for vitrified paving bricks that value obtained from the tests with the ball-and-socket bearing, which is 9,340 pounds per square inch.

4. The average modulus of rupture is 2,600 pounds per square inch.

[NOTE.—Further discussion of this paper is invited, to be received by Joseph W. Peters, 3817 Olive Street, St. Louis, for publication in a subsequent number of the JOURNAL.]

SUGGESTED FORM OF INVENTORY FOR VALUATION OF COMMON CARRIER PROPERTY

By D. F. Jurgensen,*
Member of The Civil Engineers' Society of St. Paul.

So many perplexing questions are involved in the completion of the task imposed upon the Interstate Commerce Commission by the Act of Congress, requiring the valuation of the property of carriers, that it would seem advisable to prepare a tentative form of inventory which might be used for the purpose of classifying the various methods now being proposed for the purpose of arriving at the ultimate question, viz., "Fair Value."

The Valuation Act of March 1, 1913, specifies that a tentative valuation be first prepared and submitted for consideration, quoting:

> "* * * Whenever the commission shall have completed the tentative valuation of the property of any common carrier, as herein directed, and before such valuation shall become final, the commission shall give notice by registered letter to the said carrier, the Attorney General of the United States, the governor of any State, in which the property so valued is located and to such additional parties as the commission may prescribe, stating the valuation placed upon the several classes of property of said carrier and shall allow thirty days in which to file a protest. * * *"

It is insisted by some that "Fair Value" should be determined by the so-called "Reproduction or Replacement" method, and the advocates of this method are again divided into those who claim that *reproduction* implies allowances for cost of acquisition, consequential damages, contingencies, engineering expenses, interest during construction and many

*Engineer, Minnesota Railroad and Warehouse Commission.

other items, while others contend that the "Cost of Reproduction" should be limited to the ascertainment of the present value of the items of property actually in existence, which it is claimed is the true interpretation of the decision of the United States Supreme Court in the Minnesota Rate Cases.

Another controversy has arisen with reference to the purpose to be served by the valuation or to what use the valuation may be put after it is made.

In this connection there seems to be a difference of opinion whether or not the term "Fair Value" means one amount when used as a basis for rate making and another amount when used as a basis for sale or condemnation and perhaps still another when used as a basis upon which to adjust capitalization.

The accompanying inventory is intended to suggest a form in which each of these views, as well as other contentions not necessary to specify, may find full expression. The thought underlying the suggestion is that in advance of the ascertainment of all the facts and circumstances, it is difficult, if not impossible, to come to a definite conclusion as to the propriety of the contentions advanced or the proper solution of the problem involved. If, however, an inventory of the property was prepared, which would place in parallel columns the facts and items depended on to substantiate each contention advanced, it would, it is submitted, go a long way towards the solution of the question and would, at least, simplify the work of the Commission.

The accompanying inventory is naturally a mere skeleton. The amounts used for illustration have been arbitrarily selected. The inventory is not presented as an actual inventory of the property of any carrier, nor is it at this time presented as the final inventory or tabulation to be adopted by the Commission. It is suggested as a "working form" and one which is probably adapted to be used for the tentative or proposed valuation specified in the Act of March 1, 1913, to be first submitted by the Commission for criticism and to be, perhaps, modified after the hearing provided for in the Act.

The following is a description of the inventory:

Sheet No. 1.	Column 1.	Items of property.
	Column 2.	Original cost.
	Column 3.	Appreciation.
	Column 4.	Present Value New.
	Column 5.	Cost of Acquisition and Consequential Damages of Transportation Lands.
	Column 6.	"Cost of Reproduction New" of all properties including items contended for by those who advocate inclusion of Cost of Acquisition.
	Column 7.	"Present Value New" of physical properties in existence and devoted or held to transportation business.
	Column 8.	"Depreciation"—i. e., actual existing depreciation in transportation plant compared with plant if it was new.
	Column 9.	Total "Actual Present Value" of transportation plant, based on Columns 7 and 8.

The foregoing six (6) columns of sheet one (1) have reference to *all property owned by the carrier;* the other columns it will be noted, refer to *property devoted to or held for transportation business.* The total amount of this property is found in column 7 and in the following columns deductions are made upon different bases, each column showing the total actual "present value" of the items included upon the particular basis used for that column.

It is proper to say that each column in sheet 1 subsequent to column 9 is based upon actual present value as given in column 9 and that the basis adopted for column 6 has not been carried into any of the subsequent tabulations.

Sheets 2, 3, 4, 5 and 6 are analyses of the items found in sheet 1 and require no detailed explanation.

SHEET No. 1

PROPOSED SKELETON FORM TO BE USED IN PREPARATION OF

"TENTATIVE VALUATION OF COMMON CARRIER PROPERTY"

SPECIFIED IN VALUATION ACT OF MARCH 1st, 1913

ALL PROPERTY OWNED					
		Cost of Reproduction New			
ITEM	Original Cost	Appreciation	Present Value New	Cost of Acquisition and Consequential Damages	Total
I	II	III	IV	V	VI
I. "Lands" devoted to transportation business. (Classifiable under I. C. C. Classification "I-Road.")	$ 3,000,000	$ 6,500,000	$ 9,500,000	$12,000,000	$21,500,000
II. "Construction" (Includes all items under I. C. C. Classification I-Road, except **"Land."**)	15,000,000	*14,500,000	27,900,000		*29,500,000
III. Equipment (Includes all items under I. C. C. Classification "II-Equipment.")	9,600,000	3,400,000	13,000,000		13,000,000
IV. III-General Expenditures, (as in I. C. C. Classification "Investment in Road and Equipment.")	700,000	3,900,000	4,600,000		4,600,000
V. "Miscellaneous Properties Owned" (but not devoted to transportation business.")	13,430,000	28,700,000	42,130,000		42,130,000
TOTALS	$41,730,000	$57,000,000	$97,130,000	$12,000,000	$110,730,000

*Includes $1,600,000 for "Adaptation and Solidification" of roadbed. See detail sheet No. 3. "Adaptation and Solidification" does not obtain in a new roadbed and is therefore omitted in Column IV and VII.

Continued on following page.

SHEET No. 1 —Continued.

PROPERTY DEVOTED TO OR HELD FOR TRANSPORTATION BUSINESS								
		ACTUAL PRESENT VALUE						
Present Value New as in Col. IV	Depreciation	Total	As in Col. IX Omitting Granted Right-of-Way and Land held for Future.	As in Col. X Carrying Easements at Cost	As in Col XI Omitting Construction and Equipment Acquired from Operating Expenses	As in Col. XII Omitting Construction and Equipment Acquired from Surplus Earnings	As in Col. XIII Omitting Adaptation and Solidification of Roadbed	As in Col. XIV Omitting Construction and Equipment Donated by Counties and Municipalities
VII	VIII	IX	X	XI	XII	XIII	XIV	XV
$9,500,000		$ 9,500,000	$ 7,350,000	$ 7,000,000	$ 7,000,000	$ 7,000,000	$ 7,000,000	$ 7,000,000
27,900,000	$5,300,000	*24,200,000	24,200,000	24,200,000	21,400,000	17,400,000	15,800,000	11,800,000
13,000,000	3,900,000	9,100,000	9,100,000	9,100,000	8,330,000	7,730,000	7,730,000	6,870,000
$50,400,000	$9,200,000	$42,800,000	$40,650,000	$40,300,000	$36,730,000	$32,130,000	$30,530,000	$25,670,000

St. Paul, Minn.,
May 24th, 1915.

*Includes $1,600,000 for "Adaptation and Solidification" of roadbed. See detail sheet No. 3. "Adaptation and Solidification" does not obtain in a new roadbed and is therefore omitted in Column IV and VII.

D. F. Jurgensen, Chief Engineer,
Minnesota Railroad and
Wh. Commission.

SHEET No. 2

Analysis of Item No. 1.—Lands Devoted to Transportation Purposes.

(Classifiable Under I. C. C. Classification "I-Road.")

How obtained	Original Cost	Present Value	Cost of acquisition & consequential damages	Cost of reproduction new
I	II	III	IV	V
Granted	$ Nil	$ 1,500,000	$ 3,000,000	$ 4,500,000
Condemned	100,000	400,000	400,000	800,000
Purchased & used	2,600,000	6,900,000	7,900,000	14,800,000
Purchased & held for future use	300,000	650,000	650,000	1,300,000
Easements in public streets	Nil	50,000	50,000	100,000
TOTALS:	3,000,000	$ 9,500,000	$12,000,000	$21,500,000

St. Paul, Minn.,
May 19, 1915.

D. F. Jurgensen, Chf. Engr.,
Minnesota Railroad & Wh. Commission.

SHEET No. 3

Analysis of Item No. 2.—Construction.

(Includes All Items Under I. C. C. Classification "I-Road," Except Land.)

How obtained	Original Cost	Present Value New	Depreciation	*"Adaptation & Solidification" of roadbed	Actual Present Value: Including "Adaptation & Solidification" of roadbed	Actual Present Value: Omitting "Adaptation & Solidification" of roadbed
I	II	III	IV	V	VI	VII
Capital account	$10,000,000	$15,514,000	$ 3,000,000	$ 886,000	$13,400,000	$12,514,000
Surplus earnings	3,000,000	4,636,000	900,000	264,000	4,000,000	3,736,000
Operating expenses	2,000,000	3,114,000	500,000	186,000	2,800,000	2,614,000
Cash donations from counties and municipalities	Nil	4,636,000	900,000	264 000	4,000,000	3,736,000
TOTALS:	$15,000,000	$27,900,000	$ 5,300,000	$ 1,600,000	$24,200,000	$22,600,000

*"Adaptation & Solidification" does not obtain in a new roadbed.

St. Paul, Minn.,
May 19, 1915.

D. F. Jurgensen, Chf. Engr.,
Minnesota Railroad & Wh. Commission.

SHEET No. 4

Analysis of Item No. 3.—Equipments.

(Includes All Items Under I. C. C. Classification—"II—Equipment.")

How obtained	Original Cost	Present Value New	Deprecia-tion	Actual Present Value
I	II	III	V	IV
Capital account	$ 8,000,000	$ 9,810,000	$ 2,940,000	$ 6,870,000
Surplus earnings	700,000	870,000	270,000	600,000
Operating exp'ses	900,000	1,100,000	330,000	770,000
Cash donations from counties & municipalities	Nil	1,220,000	360,000	860,000
TOTALS:	$ 9,600,000	$13,000,000	$ 3,900,000	$ 9,100,000

St. Paul, Minn.,
June 29, 1915.

D. F. Jurgensen, Chf. Engr.,
Minnesota Railroad & Wh. Commission.

SHEET No. 5

Analysis of Item No. 4.—III.—General Expenditures.

As in I. C. C. Classification of "Investment in Road and Equipment."

Item	Original Cost	Present Value New		Depreciation (On assumption that III—Gen. Ex.—Constitutes part of cost of the physical property)	Actual Present Value	
		*Basis "A"	†Basis "B"		Basis of Column III and Column V	Basis of Column IV and Column V
I	II	III	IV	V	VI	VII
Organization Expenses	$ 30,000	$ 200,000	$ 171,000	$ 34,200	$ 165,800	$ 136,800
Law Expenses	20,000	130,000	115,000	23,000	107,000	92,000
Taxes	50,000	330,000	287,000	57,400	272,600	229,600
Interest	200,000	1,310,000	1,143,000	228,600	1,081,400	914,400
Commissions	300,000	1,970,000	1,713,000	342,600	1,627,400	1,370,400
Other Expenses	100,000	660,000	571,000	114,200	545,800	456,800
TOTALS:	$ 700,000	$4,600,000	$4,000,000	$ 800,000	$3,800,000	$3,200,000

*Basis "A" computed on cost of acquisition and consequential damages as to "Lands."
†Basis "B" computed on, only "Present Value" of "Lands."

St. Paul, Minn.,
July 3, 1915.

D. F. Jurgensen, Chf. Engr.,
Minnesota Railroad & Wh. Commission.

SHEET No. 6

Analysis of Item No. 5.—Miscellaneous Properties Owned, But Not Devoted to Transportation Business.

Class	Original Cost	Present Value New	Depreciation	Actual Present Value
I	II	III	IV	V
Lands not classifiable under I. C. C. Classification, "I-Road"	$ Nil	$10,000,000	$ None	$10,000,000
Mine property	70,000	700,000	None	700,000
Securities of Other Carriers	7,000,000	10,000,000	None	10,000,000
Securities other than of Carriers	1,000,000	5,000,000	None	5,000,000
Amusement resorts	60,000	80,000	40,000	40,000
Hotels	300,000	350,000	150,000	200,000
Stores & supplies	3,000,000	3,500,000	None	3,500,000
Franchises	Nil	10,000,000	None	10,000,000
Unclassified assets of various kinds	2,000,000	2,500,000	None	2,500,000
TOTALS:	$13,430,000	$42,130,000	$190,000	$41,940,000

St. Paul, Minn.,
May 19, 1915.

D. F. Jurgensen, Chf. Engr.,
Minnesota Railroad & Wh. Commission.

Editors reprinting articles from this JOURNAL are requested to credit the author, the JOURNAL OF THE ASSOCIATION, and the Society before which such articles were read.

ASSOCIATION OF ENGINEERING SOCIETIES

ORGANIZED 1881.

Vol. 55. NOVEMBER, 1915. No. 4

This Association is not responsible for the subject-matter contributed by any Society or for the statements or opinions of members of the Societies.

SMOKE ABATEMENT—A REPORT ON RECENT INVESTIGATIONS MADE AT WASHINGTON UNIVERSITY.

By ERNEST L. OHLE, M. E.*
MEMBER OF THE ENGINEERS' CLUB OF ST. LOUIS.

[Read before the Club, October 13, 1915.]

It is scarcely necessary before a body of engineers to go into the causes for the pall of smoke that hangs almost continually over our city. Nor is it necessary to prove to a St. Louisan that smoke is a nuisance.

Our greatest fault lies in the fact that we too frequently forget that smoke can be abated and that the abatement may be, and nearly always is, a source of profit to the smoke maker as well as to the community.

Between 8,000,000 and 9,000,000 tons of soft coal, according to the Merchants' Exchange, are received annually in St. Louis, and the greater part of this is burned in the St. Louis district. The average efficiency with which this coal is burned, according to the best estimates, is probably not far from 50 per cent. With proper installations and operation there should be an efficiency of 60 per cent or a saving of 20 per cent over present conditions. This means that we are practically throwing away between 1,500,000 and 2,000,000 tons of coal a year, to say nothing of the ex-

*Professor of Mechanical Engineering, Washington University.

pense of handling this coal and the ashes formed from it. Add to this waste the cost of removing the effects of the smoke and you have an enormous sum which goes into the production of nothing of economic value.

The common oil lamp is one of the best illustrations of perfect combustion and consequent smoke prevention. The heated gases rising in the chimney produce a draft and fresh air is continually drawn in at the bottom through the hot gauze, which warms and divides it so as to insure thorough mixing with the gases from the burning fuel. Turn up the wick and the flame becomes smoky—too much hydrocarbon for the air supply; raise the chimney slightly from the bottom and again there is smoke—too much air at too low a temperature which chills the flame; insert a cool metal rod into the chimney and soot is deposited on it—chilling of the flame again and disengaging of the carbon, while the hydrogen continues to burn. Thus we see that there are three conditions necessary for perfect combustion—sufficient air, thorough mixing of the gases and a sustained high temperature. If these conditions are present in a boiler plant there will be nothing to fear from the smoke inspector.

Many of the existing plants are not equipped to give these conditions—though much more could be accomplished than is being done. A recent issue of the *Engineering Magazine* characterized as Stupidity and Waste the losses which appear in the power plant, and there is no place where a greater saving can be effected than in the boiler room. It is amazing how little information the average plant owner has in regard to the costs in his boiler room. According to one authority one fourth of the fuel bill is controlled by the fireman—how is that fourth being managed? Only by accurate records of each day's operation can any idea at all be gained as to its disposition.

According to one of the largest coal dealers in St. Louis he was furnishing five tons of coal a day to a certain plant—the operation of this plant was taken over by another company and the fuel consumption immediately dropped to four tons a day using the same fuel and under the same load conditions. One of the most notable savings was that of the Crucible Steel Company of America. Their boiler plant

was reconstructed at a cost of $130,000, and a saving of $60,000 was effected the first year.

Too frequently results obtained under test conditions

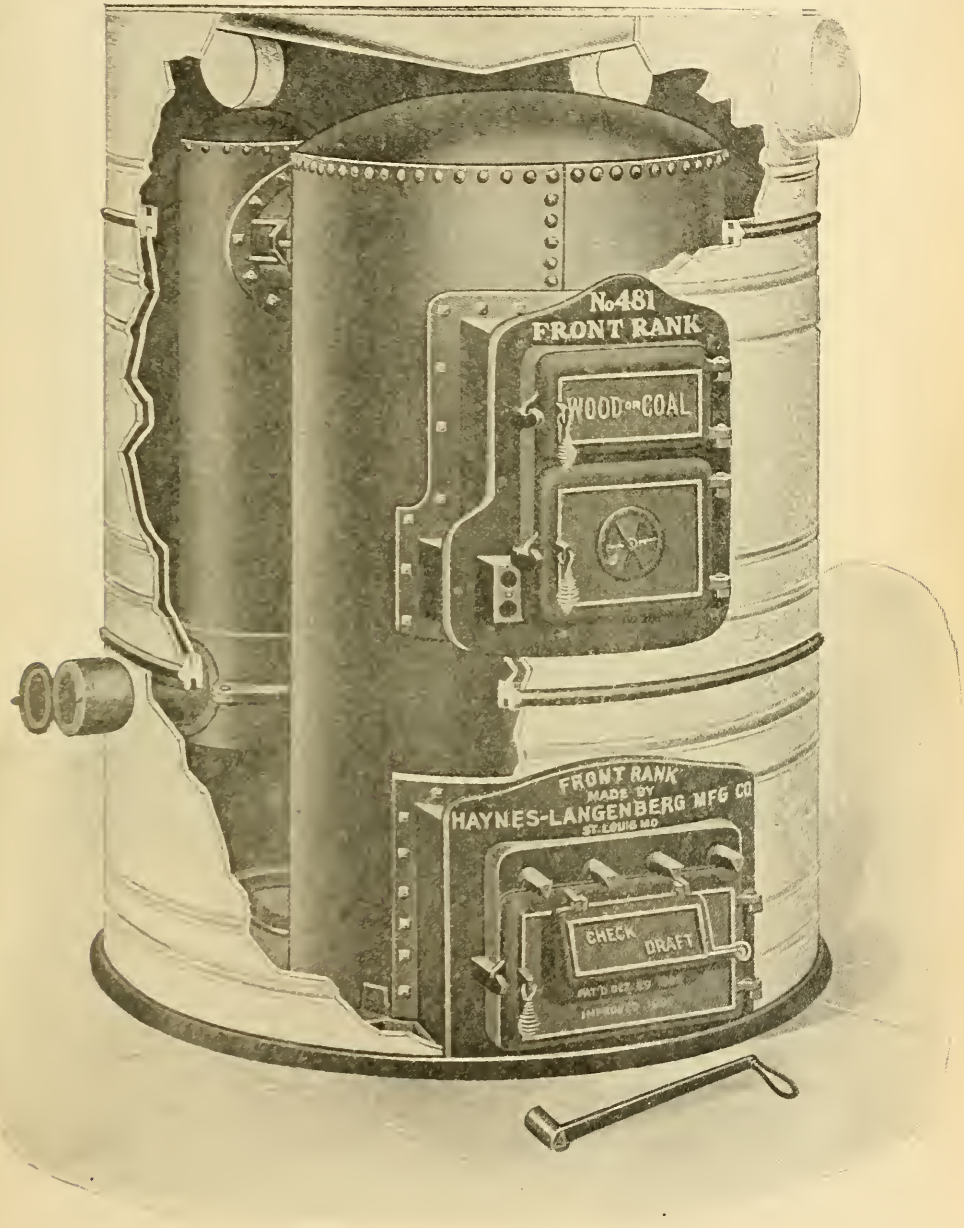


Fig. 1. Section of Front Rank Furnace.

are looked upon by responsible heads as being entirely apart from everyday interest and merely serving as a means to occupy the time of the theorist. This has been particularly true of the railway mechanical engineers, and yet notable savings have been made by some of the railroads. To quote from the Railway Review: "The Erie R. R. as long as five or six years ago began to attract attention to itself by virtue of the enviable results being attained by it in the way of fuel saving; and yet after having justified and

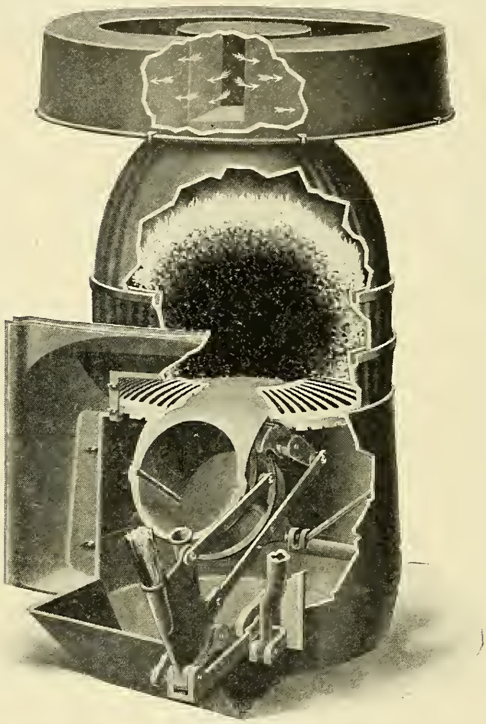


Fig. 2. Section of the Williamson Under-feed Furnace.

enjoyed a growing reputation in this regard during the intervening period, it has been found, as a result of careful evaporation tests, according to the testimony of W. C. Hayes before the recent convention of the International Railway Fuel Association, that it is possible under test conditions, to move traffic at a fuel cost of 87 pounds of coal per thousand ton-miles as against 175 to 180 pounds, under ordinary conditions of service. This situation has been de-

veloped on many another road, with what result? Why, generally the findings were looked upon as curious facts, entirely at variance with practicability and let go at that. The Erie, however, proposes to take a different stand—a study of the situation indicates to the responsible heads on that road, that the difficulty heretofore has been in a lack of supervision. Hence it is proposed to increase supervision by some 80 per cent in order that at least a goodly portion of this 50 per cent reduction in fuel cost may be realized. The cost of the added supervision has been estimated to be $125,-

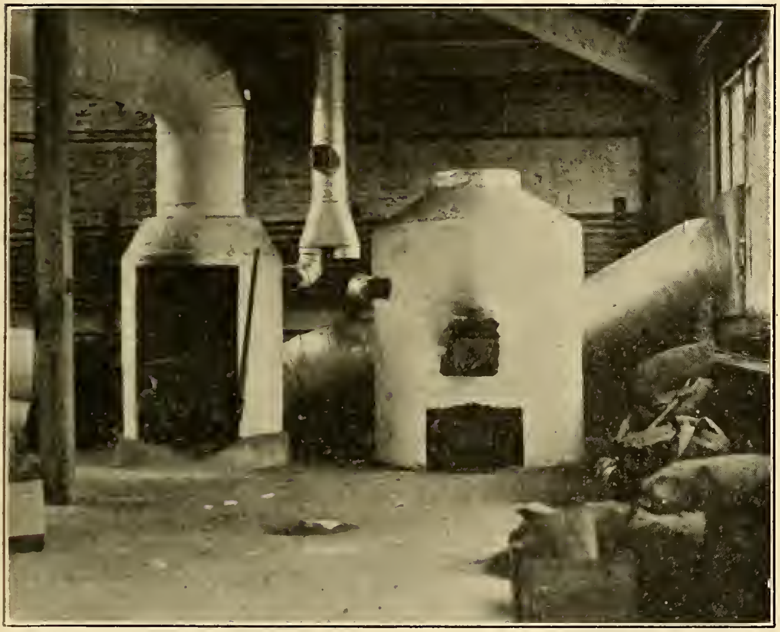


Fig. 3. Furnaces as Installed in the Laboratory.

000.00 per year. The probable saving in sight amounts to $1,250,000—a paltry 1,000 per cent return on the investment."

The brick kiln problem is one which St. Louis has to face. It has always been assumed that the brick kilns came under the provision of the ordinance permitting dense smoke where there was no known practicable device for preventing it. And yet in reply to a letter from the Smoke Abatement Committee of the Civic League, Professor Edward Orton of the Ohio State University—probably the greatest authority on

ceramics in the country says: "Regarding the smoke from brick kilns, would say, that there is no kind of fuel burning industry in which smoke control is easier than brick and pottery burning—at least in most branches of those arts. The conditions for successful avoidance of smoke are practically the conditions one finds in a good brick kiln and where a brick kiln is so handled as to smoke violently it is because the fireman either does not know how to fire properly, or what is much more commonly the case, does not want to fire properly. Correct firing takes more labor and vastly more conscience

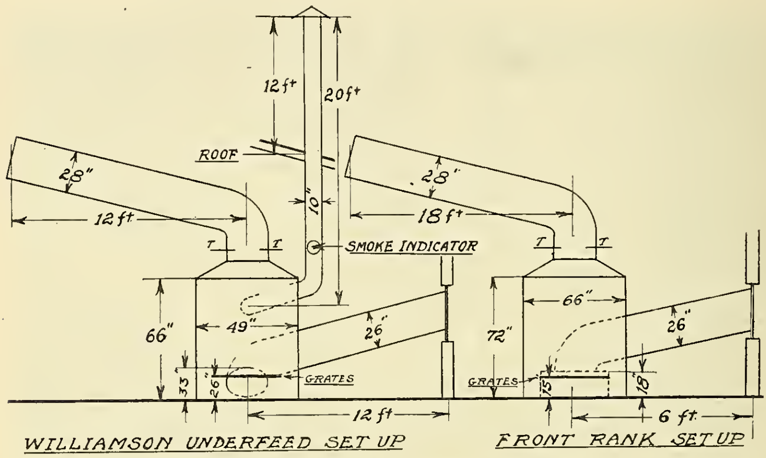


Fig. 4. Diagrammatic Sketch of Set-up.

than crude firing. It is very easy to avoid smoke by firing in small amounts at frequent intervals and with proper regulation of the air supply. But if a great deal of fuel is thrown at once into a hot fire box and the doors closed nothing under heaven is going to prevent a great cloud of black smoke. The latter way is the easy way and therefore smoke is common."

In our investigations last spring a large number of power plants were visited in company with an inspector from the City department and smoke observations made. The installations that were examined included fire and water-tube boiler plants and the furnaces ranged through hand fired of the plain grate and down draft types and automatic stokers of the chain grate, inclined grate, and underfeed types.

It was found that some of the best equipped plants were among the worst offenders, due to careless operation and

wrong sized coal, and that some of the poorly equipped plants were giving practically no trouble at all, due to careful operation or to the simplest of devices. A smoke indicator showing the condition of the stack at all times was found to be an especially efficacious device in its effect on the fireman. Steam jets also gave good results though the cost of operation is high where they are allowed to run continuously. In one instance it was found possible to completely clear a stack in ten seconds by simply cracking the furnace doors.

During the heating season a great deal of the smoke in the residence section comes from the so-called low pressure

SMOKE INDICATOR

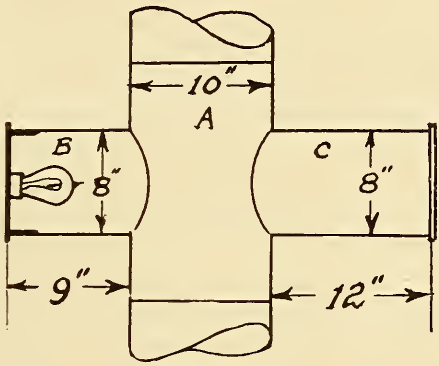


Fig. 5.

and the residence heating plants. While the amount of smoke emitted from a stack may not be so much at any one time the continuity of emission makes a large total volume.

In order to get some idea of the number of smoking stacks and the amount of smoke emitted, observations were made from advantageous points in the West End section of the City, the results follow: March 2; point of observation, 6100 Delmar ave.; 64 stacks in sight; 10 smoking average density between 1 and 2; observation lasted from 1:10 till 3:05; all stacks still smoking at the end of the observation. March 4; same point; 21 of 64 stacks smoking; 5 violations; 19 reached a density of 3 or more; observation from 1:30 till 4:00; all still smoking at the end of the observation. March 5; Washington and Grand ave.; 14 stacks smoking; grade

ranging from 2 to 5; time, 5:16 to 5:44; still smoking at end of observation. March 8; roof of Washington Hotel; 81 stacks smoking between 1:10 and 1:25; including one large stack with No. 4 and three large stacks with No. 3.

These observations show that a large percentage of the stacks are smoking continually and it could scarcely be otherwise with the kind of coal used and the amount of attention given to the furnaces. The furnaces are fired only two or three times a day and they receive no attention between firing periods.

At the suggestion of the Women's Smoke Abatement Committee and through the kindness of the Haynes-Langenberg Mfg. Co., of St. Louis, who furnished one of their Front Rank hot air furnaces and the Williamson Heater Co., of Cincinnati, Ohio, who furnished one of their under-feed hot air furnaces, a series of tests were run at Washington University to determine what coals could be burned smokelessly and the amount of attention necessary and the efficiencies of the furnaces.

Figure 1 shows a section of the Front Rank furnace, figure 2 a section of the Williamson under-feed furnace. The furnaces were set up side by side in the northeast corner of the Mechanical Engineering laboratory at the University as shown by figure 3, and diagrammatically in figure 4.

The furnaces were quite thoroughly insulated by three thicknesses of asbestos paper. Cold air was taken from the outside through a 26 inch diameter duct about 6 ft. long for the Front Rank furnace and about 12 ft. long for the under-feed. The top of each furnace was coned and the hot air taken away by a single duct 28 inches in diameter which fitted over the apex of this cone. The hot air pipe was about 18 ft. long for the Front Rank furnace and about 12 ft. long for the under-feed.

The smoke stack was made of galvanized iron and was 10 inches in diameter. It was placed between the two furnaces and forked at the bottom so as to serve either. When one furnace was being tested the leading to the other was disconnected and closed with a tight fitting cover. Figure 3 shows the Williamson furnace connected up for testing.

Figure 5 is a drawing of the smoke indicator. "A" represents a cross-section of the stack; "B" and "C" round pipes

fitted to the stack with their centers in a direct line. The pipe "B" is closed with a tight-fitting cover to which is attached an incandescent electric bulb, while the end of "C" is closed by a plate of frosted glass. When there is no smoke in the stack the frosted glass shows a clear yellow light, but when there is smoke the rays of light from the lamp are cut off and the glass becomes dark.

The following was the general procedure in all tests: In starting the fires a weighed amount of wood and shavings was used and when this was well ignited coal was added. A value of 5,800 B. t. u. was allowed for the wood and shavings. Both furnaces were started in the same manner, the under-feed device of the Williamson heater not being used until a good bed of coals was established.

Readings of the various temperatures and of the air velocity were taken every five minutes. The flue gases were analyzed frequently. The humidity of the air was taken every half hour, and a continuous record was kept of the smoke, grading according to the Rinelman chart.

A shovelful of coal at each firing was placed in a covered receptacle and sampled according to the A. S. M. E. code at the end of the test. All of the fire was dropped at the end of the run and, together with the ashes, was placed in a large tightly covered can to prevent further burning. When cool this was sampled in the same manner as the coal.

The hot air temperature was kept as nearly constant as possible by regulating the check draft and the damper, the plan being to maintain a temperature difference of about 130 degrees between the cold and the hot air.

The quantity of air heated was measured at the entrance to the cold air duct, the cross-sectional area of the duct being divided into four inch squares and a calibrated anemometer used to get the average velocity of the air. The specific heat and the weights per cu. ft. of the air were taken from the Carrier tables.

The following are the proximate analyses of the coals tested made through the kindness of the City Testing Laboratory:

No.	Kind	Volatile	Fixed-Carbon	Ash	B. t. u.	
1.	Coke	2.19	91.99	5.82	11,107	Dry.
2.	Anthracite	8.83	82.10	9.07	12 906	As rec'd.

3. Arkansas Lump	14.78	75.61	9.61	13,539	"	"
4. Briquettes	19.9	73.30	6.80	14,903	"	"
5. Admiralty Nut	22.4	70.00	7.60	14,323	"	"
6. Inland Valley Pea	35.98	53.44	10.58	12,246	"	"
7. Standard Lump	46.2	43.0	10.80	11,690	"	"

The coke, anthracite, Arkansas lump, briquettes, Admiralty, and Inland Valley pea coals were tried in the Front Rank furnace. With the coke and anthracite, of course, no difficulty arose, the only smoke made coming from the wood that was used in starting the fires. The fires and temperatures were easy to regulate.

With the other coals it was found possible to fire any of them without at any time violating the ordinance providing the fire was brought to a state of incandescence before putting on the fresh coal and then cracking the door of the furnace for a few minutes after firing.

The greatest density of smoke was a No. 4 when running on the Inland Valley pea coal and this lasted for only half a minute, two minutes after firing, then dropped to a No. 2, and in eight minutes the density was only No. 1.

The under-feed furnace is designed primarily for coals higher in volatile than coke and anthracite and only the briquettes, Admiralty, pea, and standard lump were used.

When using the under-feed mechanism for firing, the greatest density reached was a No. 3, and this lasted for two minutes, at the end of 25 minutes the stack was clear. This was with the pea coal. With the briquettes and Admiralty the density never exceeded No. 1.

When the coal designated Standard lump was tried it was not possible to check the smoke and the test was abandoned after 3 hours.

Our tests would show then, that, with the exception of standard lump, furnaces of the types tested could burn coals with analyses similar to those tested without objectionable smoke providing reasonable care is exercised in their operation.

[NOTE—Further discussion of this paper is invited, to be received by Joseph W. Peters, 3817 Olive Street, St. Louis, for publication in a subsequent number of the JOURNAL.]

RECENT PROGRESS IN BOILER INSTALLATIONS AND SOME RESULTS OF FURNACE INVESTIGATIONS.

By Wm. A. Hoffman.*
Member of the Engineers' Club of St. Louis.

[Read before the Club, October 13, 1915.]

It is not the intention of the writer to give to the Engineers' Club full and complete data of any test of any particular smoke abating device, but to give a description of installations made in St. Louis recently, considered and accepted as the best construction for the purpose of generating power burning bituminous coal without making dense smoke.

Chicago and St. Louis have been prominent in the number of chain grate installations. In the past three or four years in the East the new type under-feed stoker has been developed and is rapidly being installed in the new power stations and in the reconstruction of old stations in that section.

The claims for these new type stokers are: Smokelessness; low maintenance; low coal rates; great overload capacities, and the responding to sudden fluctuations of load quickly.

In April, 1915, at the plant of the National Lead Co., on Manchester ave., this city, was installed a 400 h.p. B. & W. water-tube boiler, having a five retort Taylor Stoker. The boiler was set having 10 ft. under the front header. There are three vertical passes, with rear up-take on top.

This was the first installation of the new type under-feed stoker and has demonstrated that this stoker can burn the coal of this field as well as the better grades of coal in the East. The owners report its operation as being satisfactory and capable of responding quickly to sudden fluctuations of load as well as maintaining over-loads for long periods. Its smoke abatement record is quite satisfactory.

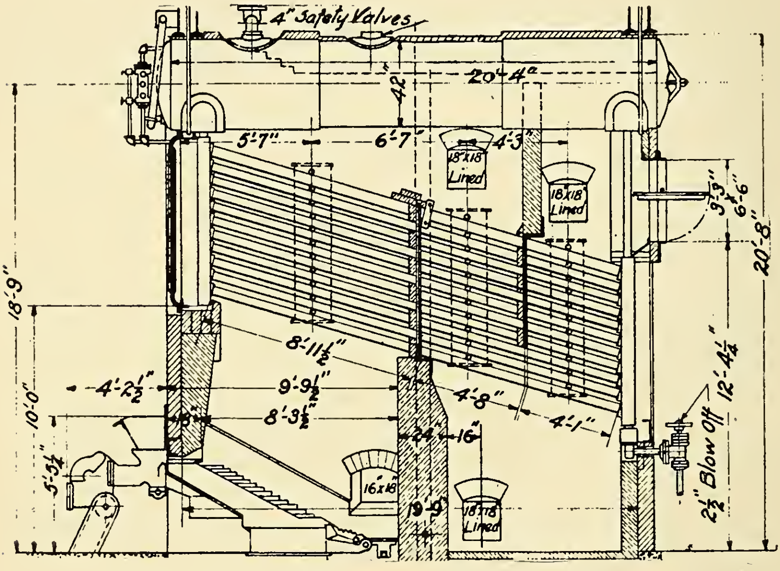
In the new By-Product Coke Plant of the Laclede Gas Light Co., at Carondelet, in May, 1915, was installed a similar stoker under a 508 h. p. Edge Moor water-tube boiler, the boiler having 9 ft. under the front header. There are four vertical passes with rear down-take into an under-ground flue leading to a 9 ft. by 220 ft. stack. It was the intentions of the Gas Company to burn coke breeze under this boiler. I am informed that this fuel did not prove satisfactory.

In this boiler plant are Illinois chain grate stokers under

*Inspector of Boilers, Elevators and Smoke Abatement of the City of St. Louis.

two boilers of the same size and similarly baffled, in which bituminous coal is used. The furnace construction is new in this section. Over the grate is a flat arch 7 ft., 0 in. long, 15 in. from the grate in front and 27 in. from grate in rear. The bridge-wall is run up vertically past the rear of the arch, then slants to rear of the first pass. The distance from end of arch and vertical face of bridge-wall is 3 ft., 0 in.

The objections to chain grates by engineers is due to this type of grate allowing air to enter the furnace through the back portion of the grate. As ordinarily operated the coal

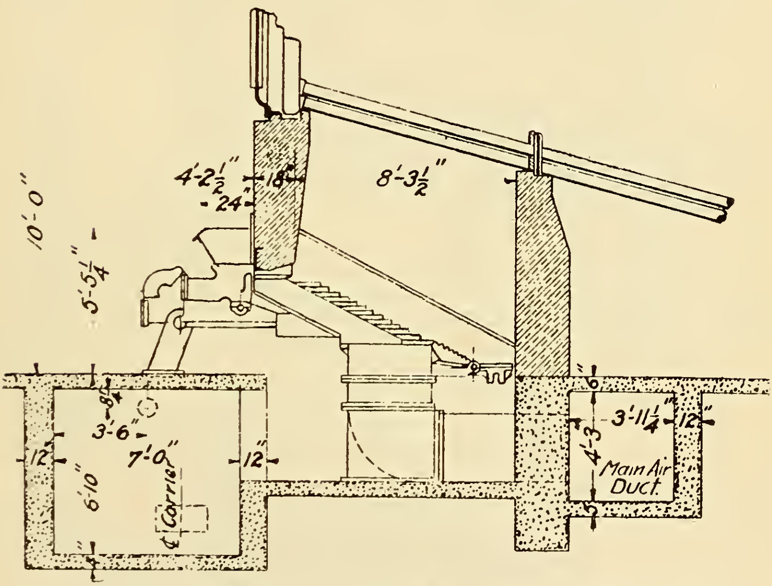


Taylor Under-feed Stoker and Babcock & Wilcox Boiler.

passes under the arch and ignition occurs, the volatile gases begin to distill off, flowing under the arch and passing to the heating surface without being mixed with the air that has entered the furnace through the rear of the grate. With the throat construction, the air entering at the rear of the grate, and the volatile gases, will be forced to mix in this zone of high temperature. This construction produces a Bunsen burner effect, resulting in a smokeless furnace and high economy. The vertical bridge-wall has a beneficial effect not only on smoke, but on capacity to burn the coal.

An illustration of long flame travel and mixing of gases,

is in the power plant of the Rice Stix Dry Goods Co., Tenth and St. Charles streets, where the installation consists of two 350 h. p. Edge Moor water-tube boilers with Roney stokers. The boilers are set having 8 ft., 0 in. under the front header. The lower row of tubes are bare from front header to bridge-wall, with enclosing tile from bridge-wall to first pass in rear. The baffling is vertical from the rear of the boiler in three passes; the gases escape in front up-take on top of drums. The stack is 5 ft., 6 in. by 200 ft. high. Four feet back of the bridge-wall is a two span arch of liberal area which breaks up and thoroughly mixes the gases coming over the bridge-wall on their way to the vertical rear pass.



Taylor Under-feed Stoker, Showing Arrangement of Air Ducts.

The chimney of this plant is practically smokeless—it is one of the best, if not the best, in this respect, in the down-town section.

A new type of boiler in this section was installed in the plant of the Union Brewing Co., in August, 1914, and consists of three 500 h. p. Wickes vertical water-tube boilers with chain grate stokers. In addition to the 5 ft., 0 in. arch over the chain grate, there is a combustion chamber 8 ft., 0 in. long and 7 ft., 0 in. above the grate for the gases to mix in

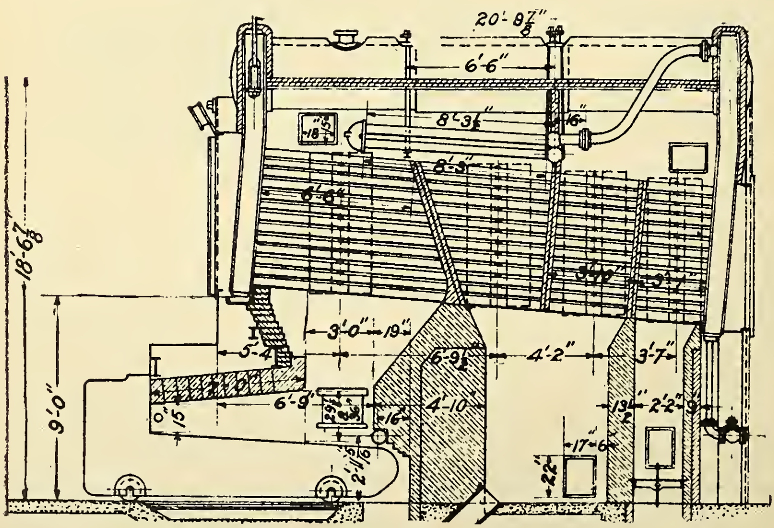
before passing to the two vertical passes of the boiler. The gases escape from the second vertical pass near the bottom of the boiler, thence to a stack 7 ft., 6 in., in diameter and 185 ft. high.

It may be of interest to the members to give at this time a list of boiler installations, plans of which were approved by the Smoke Abatement Department, and permits issued for a twelve-month period ending April, 1915.

Down Draft Furnace (Shell Boilers)	57
Chain Grate Stokers	18
Incline Stokers	6
Under-feed Stokers	3
Baffle Walls and Steam Jets	2
Baffle Walls only	6
Cast Iron Down Drafts	140
Cast Iron Straight Grate, smokeless fuel	22
National Stoker-Grate	3
Total	257

Down Draft Boilers	197	76.5%
Stokers	27	10.5%
Baffle Walls	8	3.1%
Cast Iron, Ordinary Grate, smokeless fuel	22	8.6%
National Stoker-Grate	3	1.3%
Total		100.0%

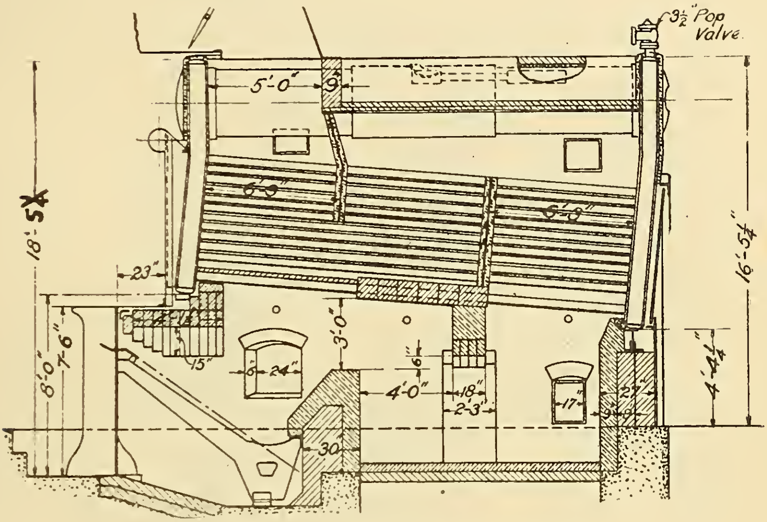
Powdered fuel is now claiming the attention of combustion engineers. St. Louis is fortunate in having a plant using bituminous coal in this form at the new Rolling Mills



Chain-grate Stoker and Edge Moor Boiler.

of the St. Louis Screw Co., on North Broadway. This plant is equipped with crushers, pulverizers and dryers located in a separated building. The pulverized coal is conveyed to four melting furnaces of 25 tons capacity each 24 hours. The plant has been in operation since the early part of this summer and is the only one west of Pennsylvania which uses powdered fuel in melting furnaces. It is needless to say the stacks of these furnaces are smokeless.

There is now being equipped on a C. & N. W. locomotive at Chicago, apparatus for the purpose of burning powdered



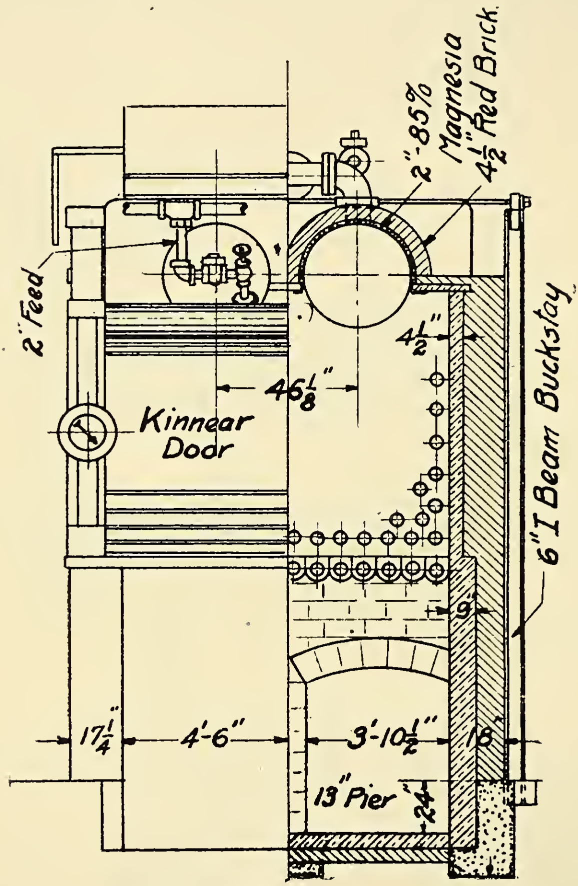
Roney Stoker and Edge Moor Boiler.

coal. You can readily understand, in the absence of good furnace construction on a locomotive, why interest is being taken in this form of burning coal. I am informed there is in operation, in passenger service west of Albany, N. Y., a New York Central locomotive obtaining good results using fuel in this form. The engineers of railroads are anxious to know the results on these two trial installations. There are many features to be worked out in using powdered coal on locomotives, which can only be determined by tests extending over a long period.

There are 495 locomotives operating in and out of St. Louis, 82½ per cent being equipped with smoke abating devices. In 1911, 38 per cent were thus equipped; in 1912,

52 per cent; in 1913, 62½ per cent; and in 1914, 82½ per cent.

Progress in smoke abatement by locomotives can be compared by the per cent of violations, and will indicate the effect of equipping locomotives with devices, the reporting of violations by the department to the railroads and the co-operation of the railroad officials and locomotive crews. In



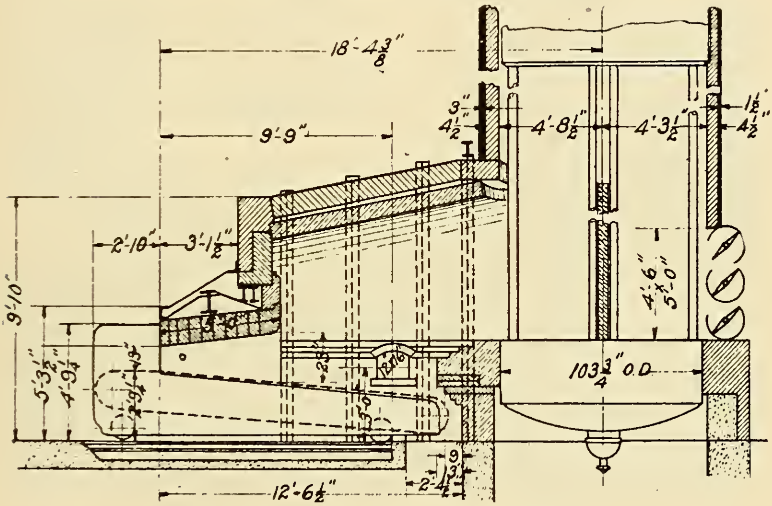
Roney Stoker and Edge Moor Boiler.

January, 1912, of 1,222 observations, 534 or 43.7 per cent were violations. In January, 1915, of 1,425 observations, 162 or 11.3 per cent were violations. The violations per 1,000 observations were 162, in 1912, and 96, in 1914. The per cent of violations in 1914, was 9.6 per cent. Roads operating passenger trains only, the violations were 3½ per cent or 35 per cent per 1,000 observa-

tions. A violation is the emission of dense smoke for one minute or more for any observation period.

The number of observations of chimneys from which dense smoke was emitted from power and heating plants and railroad locomotives were as follows: 12,709 stack observations in 1914 as compared with 8,671 in 1913; 36,031 observations of locomotives in 1914 and 34,928 in 1913. Special visits, 3,506 in 1914 and 2,695 in 1913.

The stack observations of power and heating plants are of chimneys emitting dense smoke only—no observations are recorded of chimneys not emitting dense smoke. A record of chimneys not emitting dense smoke compared with chim-

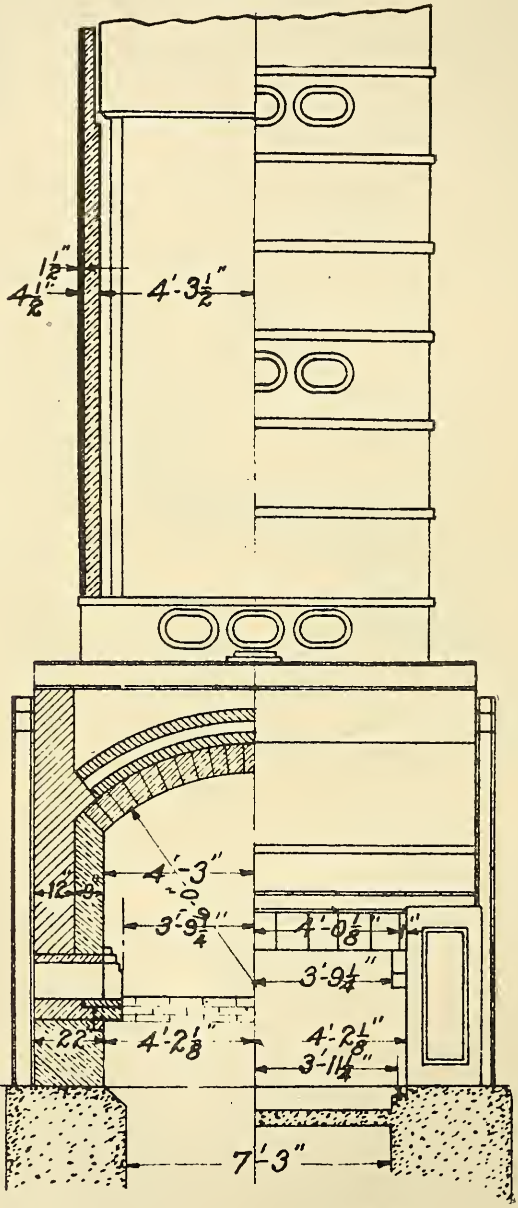


Chain-grate Stoker and Wickes Boiler.

neys emitting dense smoke would be a fair comparison of progress made in smoke abatement by power and heating plants, but we have not the facilities for obtaining and maintaining such a record. The observations of locomotives are of all locomotives observed, whether emitting dense smoke or operating without emitting dense smoke.

The switching and freight locomotives are responsible for 80 or 90 per cent of the smoke from locomotives. Ninety per cent of the observations are made of locomotives in these two classes of railroad service. Switching and freight locomotives are always operating for long periods in the various

yards within the city limits. Many roads are now operating locomotives in passenger service with monthly records of no violations. The record of one railroad I desire to mention



Chain-grate Stoker and Wickes Boiler.

particularly. Its service is principally operating passenger locomotives. Of 724 observations, 11 or 1½ per cent were violations, the violations being 15 per 1,000 observations.

With the best known devices installed, operated by the engine crews and hence subject to their carelessness for results, and allowing for the variable loads and difficult conditions under which locomotives usually operate, it cannot be expected that the smoke from locomotives will ever be abated to the extent that has been done in stationary plants.

In making furnace investigations the Department was naturally limited in the number made. I am pleased to report

Powdered Fuel Apparatus on Melting Furnace, at St. Louis Screw Co.

to the Club the results of a test made in a manufacturing plant and of tests made in one of our large railway power plants. The results of the latter are particularly interesting due to the unfavorable conditions for smoke abatement.

The instruments used by the Department in furnace investigations are as follows:

An Ellison Differential Draft Gauge and a Foxboro Recording Draft Gauge, each graduated to read from 0 to 1½ in. of water; a Hays Improved Flue Gas Analyzer reading to 0.2 of one per cent, and a double scale high reading Thermo-electric Pyrometer. This Pyrometer is made by the Industrial Instrument Co., and is equipped with a Platinum-Rhodium

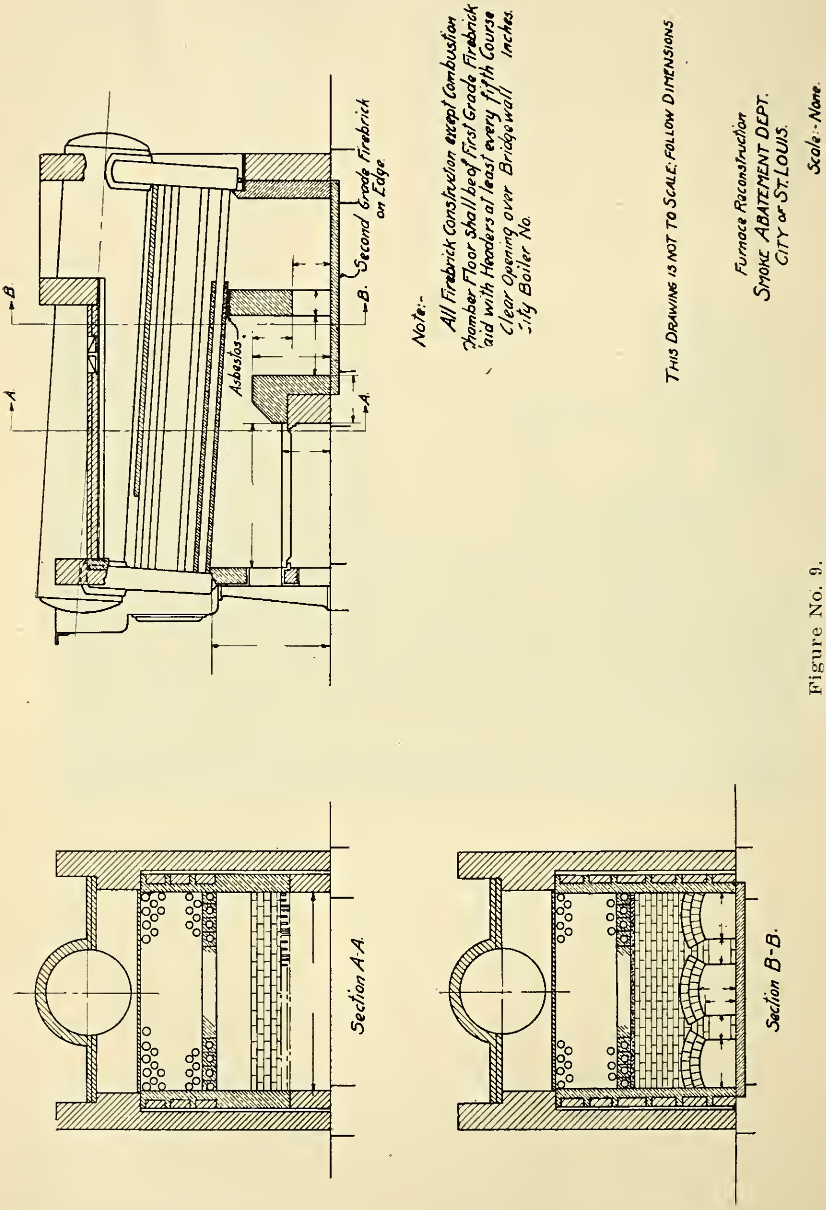

B
A
Asbestos
B.
A.
Second Grade Firebrick on Edge
Note:-
All Firebrick Construction except Combustion
hamber Floor shall be of First Grade Firebrick
aid with Headers at least every fifth Course
Clear Opening over Bridgewall Inches.
ity Boiler No.
THIS DRAWING IS NOT TO SCALE: FOLLOW DIMENSIONS
Furnace Reconstruction
SMOKE ABATEMENT DEPT.
CITY OF ST. LOUIS.
Scale:- None.
Section A-A.
Section B-B.

Figure No. 9.

Thermo-Couple, 28 in. long and with a base metal fire-bar 48 in. long. The instrument reads from 0 to 3,000 degrees Fahrenheit, when the Platinum-Rhodium Couple is used, and from 0 to 1,800 degrees Fahrenheit, when the basemetal fire-bar is used.

In its investigations, the Department is forced to be content with such tests as do not require a great amout of preparation.

Evaporative tests, in addition to the type of tests described in this paper, would be exceedingly valuable. They are, however, out of the question, owing to a lack of equipment,

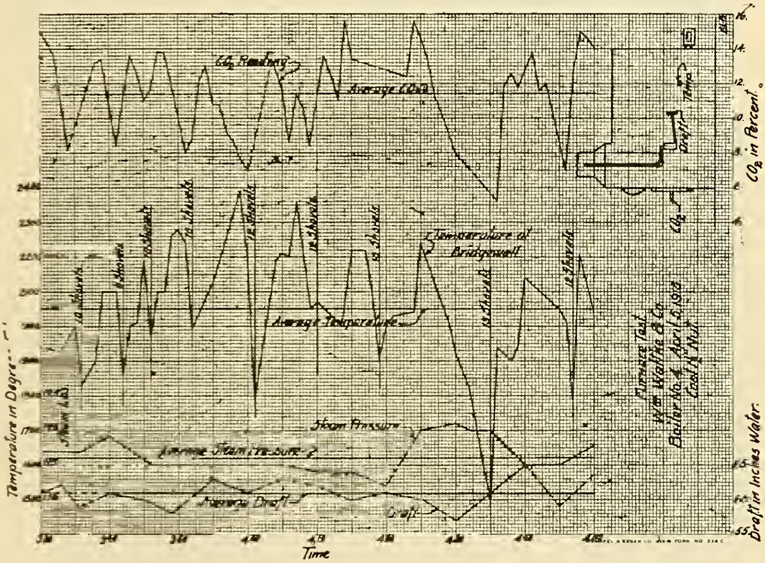


Figure No. 10.

a lack of enough trained men to conduct the tests, and the impossibility of arranging boilers for test without expense and considerable inconvenience to owners. As the Department is interested primarily in producing efficient combustion, the utilization of the heat produced in the process being of secondary importance, evaporative tests are not essential to our work.

Figure No. 9 shows a type of furnace which has been installed under many hand-fired water-tube boilers in St. Louis, and has given satisfactory results in smoke abatement. The construction consists of a baffle-wall, having a series of arched

openings extending from the floor of the combustion chamber to within 12 or 13 in. of the top of the bridge-wall. The combustion chamber is paved and the side and back walls lined with firebrick. The drawing shows the lower row of tubes enclosed in box-tile. In later forms of construction, T-tile have been substituted for the box-tile over the grates, the box-tile enclosing only that portion of the tubes between the baffle-wall and the front face of the bridge-wall.

Figure No. 10 shows graphically the results of a test upon a furnace of this latter type.

Draft readings were taken at the base of the stack which rests upon the walls of the setting directly over the up-take.

Temperature readings were taken through a one inch pipe inserted through the side wall of the furnace at the bridge-

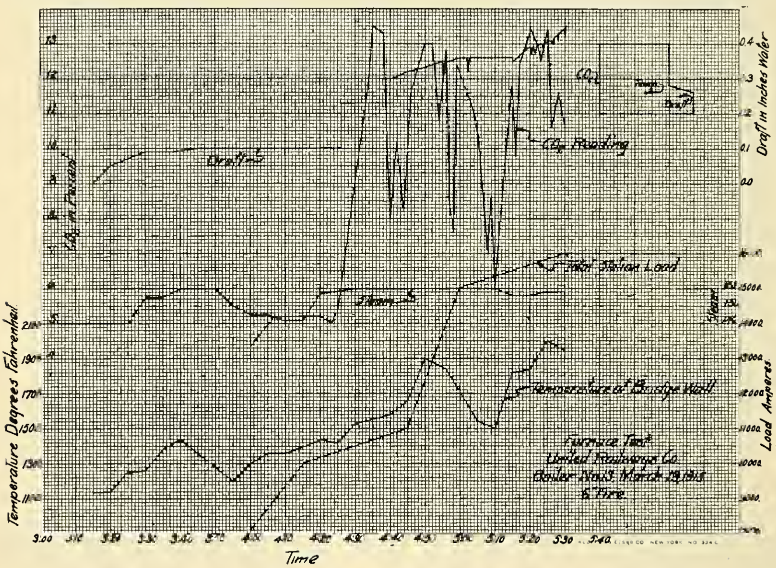


Figure No. 11.

wall, halfway between the top of the bridge-wall and the tubes.

CO_2 determinations were made every minute during the test, the flue gas samples being obtained through a stay-bolt hole in the rear water-leg, between the first and second row of tubes.

No attempt was made to coach the fireman or to interfere in any way with his usual handling of the boiler.

Special smoke readings were not attempted, but after each firing, the stack was observed through a skylight directly over the fireman's head, and the emission of dense smoke prevented by opening, or, as it is termed "cracking" the fire doors about three inches.

The doors remained cracked for a period averaging three minutes after each firing, and were then closed until the next firing period.

Time of firing and the total number of shovels of coal are indicated upon the chart.

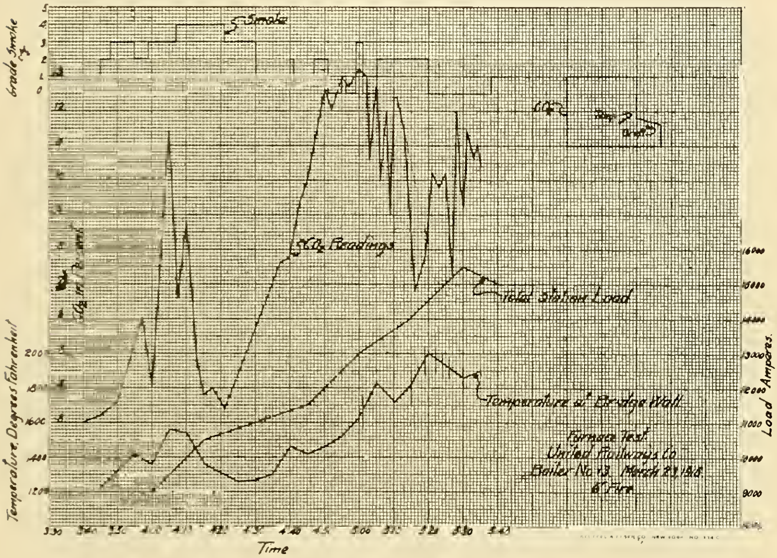


Figure No. 12.

All furnace doors, three in number, were fired at each firing period by the spreading method, a 1½ in. clean nut coal being used.

Many engineers have questioned the economy of furnaces of this type when fire doors are cracked to prevent smoke emission. It is, therefore, interesting to note that the maximum CO_2 readings were obtained during the periods of air admission over the fire through the fire doors.

The furnace temperature increased also during this period of air admission, the maximum reading after each firing lagging behind the maximum CO_2 reading, as is to be expected.

The following average readings were obtained:

Draft	0.61 inches.
Steam Pressure	116 pounds.
Temperature of furnace	2,050° Fahrenheit.
CO_2	11.4 per cent.

At 4:20 p. m. the steam pressure ran up, due to shutting off a tank using live steam. The furnace was not fired again for fifteen minutes, causing the furnace temperature and the CO_2 reading to decrease as is indicated in the chart.

Higher average readings of CO_2 and temperature would

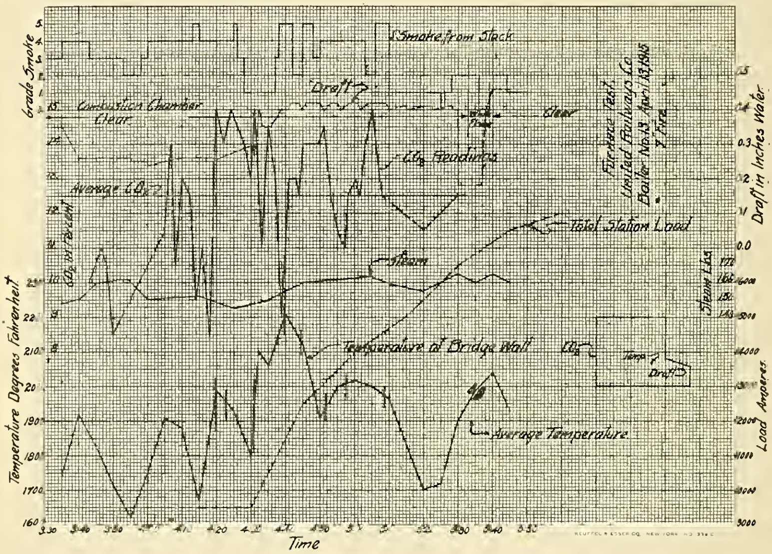


Figure No. 13.

have been obtained if the boiler had been operated normally during this period. However, no apology need be offered for these averages, as they represented far better conditions than exist in the average boiler plant.

As has been previously stated the fuel used during this test was a clean 1½ in. nut coal. The Department has found nut coal an extremely difficult fuel to handle smokelessly, and its use is therefore not encouraged.

During the spring of 1915, an extended series of tests was made by the Department upon the boilers of the United Railways Co., at Park and Vandeventer avenues.

This plant contains 16 horizontal-pass O'Brien water-tube boilers, each having 228 3½ in. tubes, 18 ft. long. They are rated at about 410 h. p. and are equipped with Green Chain Grate Stokers. A large self-supporting steel stack serves all boilers. The connections from the stack to boilers are made through two overhead breechings each carrying four batteries of two boilers.

The conditions under which this plant operates are extremely unfavorable for smoke abatement. Except for two periods of peak load of approximately three hours each, at

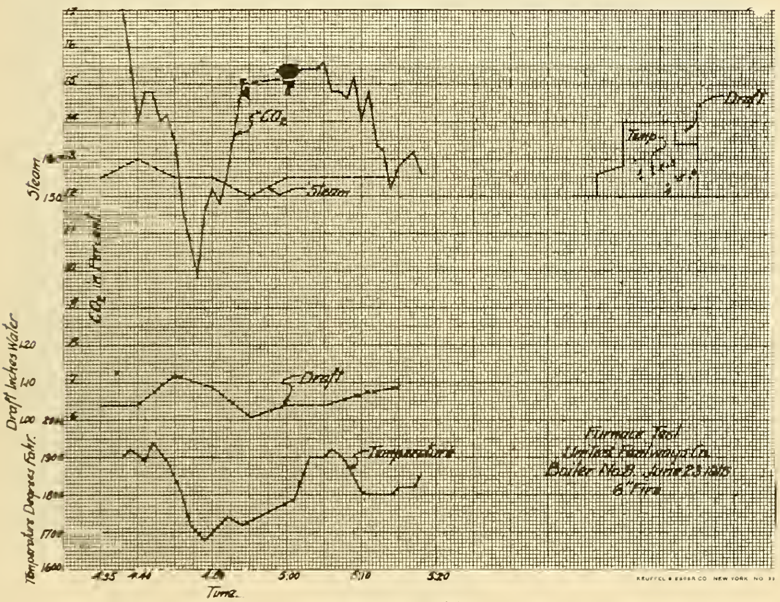


Figure No. 14.

about 6:00 a. m. and 4:00 p. m., the fires under all boilers are banked. When the fires are brought out of bank, dense smoke is produced for a considerable length of time. This smoke is particularly noticeable in the afternoon.

At their request, the Department undertook to assist this Company in devising means for bringing the boilers out of bank with a minimum of dense smoke. Tests were run during the starting periods to determine the conditions prevailing. The firemen were cautioned to make no change in the usual methods of handling the boilers.

The three tests upon boiler No. 13, Figures, No. 11, 12

and 13, are representative of conditions under ordinary methods of bringing these boilers on, while the two upon boiler No. 8, Figures, No. 14, and 15, represent conditions while the boilers are being forced.

Briefly, the Company's method of meeting the afternoon peak load is as follows: At about 3:30 p. m., the stokers are started and the fire run back to the bridge-wall. This is done with the dampers closed in order to avoid an inrush of cold air through the rear of the grates. Dampers are kept closed

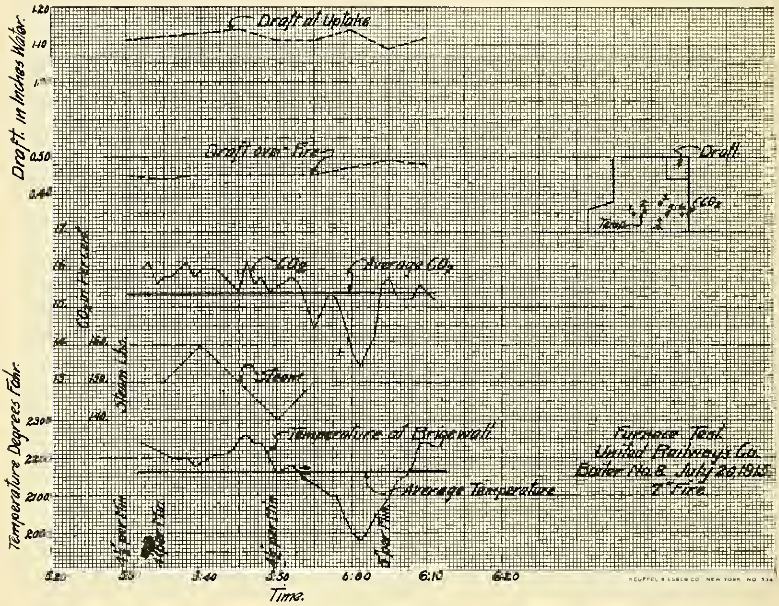


Figure No. 15.

until there is a call for steam. At about 3:45 p. m., the auxiliaries are put on, and a few minutes later the first large generating unit is started. The load comes on between 4:00 and 4:30 and additional units are started in succession to carry it.

Figure No. 11, shows the results obtained during a period as described. Each step in the chain of operations may easily be followed. The draft curve shows a gradual increase in draft over the fire from 3:15 to 3:45, due to sealing the rear end of the grate. An increase in temperature in the combustion chamber and in steam pressure naturally follows. The results of a call for steam, and consequently the pump-

ing of comparatively cool feed water into the boiler is shown by a drop in furnace temperature at 3:40 and a reduction in steam pressure later. The damper was opened at 4:26 and the stoker speed increased, which immediately shows in the CO_2 curve.

The draft readings were taken by the recording draft gauge from a point midway in the length of the arch. Temperatures were obtained at a point over the bridge-wall halfway between the tubes and the top of the wall.

Steam gauge and temperature readings were taken every five minutes.

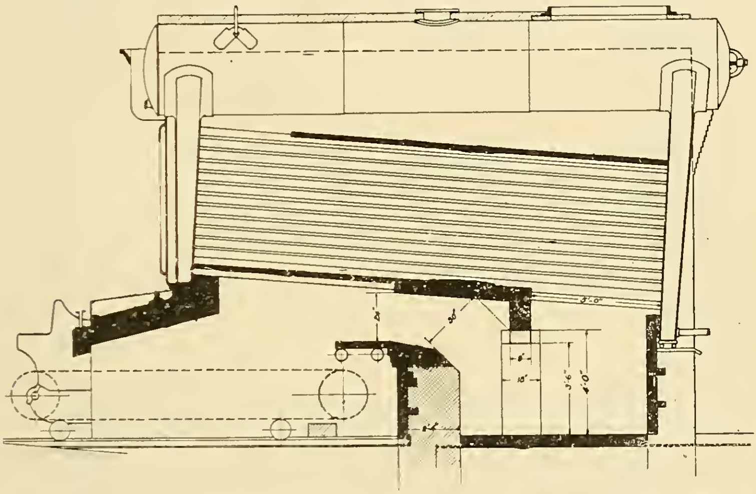


Figure No. 16. Furnace Reconstruction at United Railways Co. Central Power House.

CO_2 readings were taken every minute, the flue gas samples being obtained from a stay-bolt hole in the rear water-leg above the second row of tubes.

The station load curve was plotted from the load sheet furnished by the Company.

The CO_2 curve is extremely irregular, the high reading being 13.5 per cent and the low 6 per cent, considering only the part of the curve from 4:30 to 5:30 p. m.

The vertical marks upon the temperature curve indicate times at which the fire was raked through the inspection door. The CO_2 curve shows that, as a rule, these rakings improved the condition of the fire. A study of the fires to-

gether with a study of this and similar charts clearly indicated the advisability of increasing the thickness of fires, as it was quite evident that the rear end of the grate was insufficiently sealed.

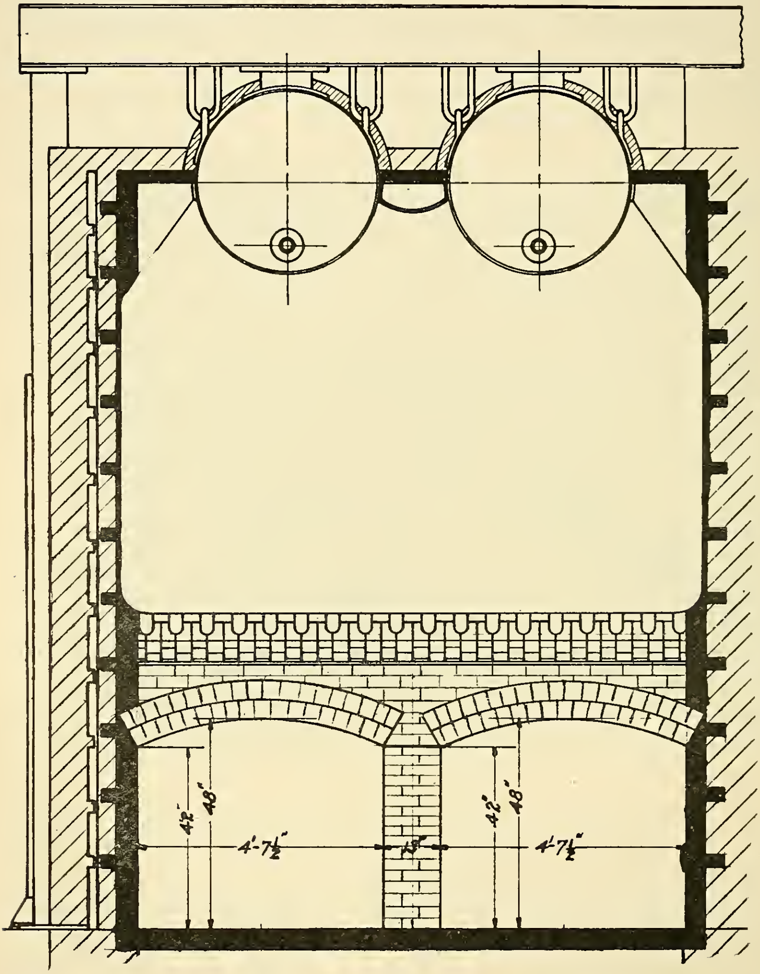


Figure No. 17. Furnace Reconstruction at United Railways Co. Central Power House.

The maximum furnace temperature obtained was 2,000° Fahrenheit.

Figure No. 12, shows the results of a test several days later. These curves follow the same general form as those

previously described. The CO_2 curve of this test also shows the effect of raking the fire.

Here again the CO_2 curve is extremely irregular, the high reading being 13.2 per cent.

The maximum temperature reached in the combustion chamber was 2,000° Fahrenheit.

A series of graded smoke readings is shown at the top of the Chart. The characteristic stack performance is clearly shown, the smoke emitted being from all the boilers in operation, usually fourteen. The Chart clearly shows that as the settings become hot, the density of the smoke decreases.

Figure No. 14 shows the results obtained from boiler No. 8, with a chain speed of 3 in. per minute. During this test, conditions in the furnace were observed through inspection holes 2½ in. in diameter, marked 1, 3, 4, 5 and 6 upon the sketch in Figure No. 14. The inspection holes were located as follows: Hole No. 1, at the bridge-wall, about halfway between the top of the wall and the tubes; hole No. 2, about 18 in. in rear of hole No. 1, about 4 ft., 6 in. above the combustion chamber floor; hole No. 3, about 4 ft., 6 in. in rear of hole No. 1, about 4 ft., 6 in. above the floor; hole No. 4, directly beneath hole No. 3, about 2 ft. above the floor; hole No. 5, at the end of the tube-tile, 3 ft. above the floor; hole No. 6, at the rear wall of setting 3 ft. above the floor.

At all times during the test, the combustion chamber was filled with intensely white flame, making it impossible at any point to see the setting wall opposite the inspection holes.

The CO_2 curve shows a maximum of 17 per cent and a minimum of 9.8 per cent, averaging 13.8 per cent.

The maximum temperature was 1,940°, the minimum 1,680°, averaging 1,830°.

After careful study of these and other tests, the Department recommended, as an experiment, additional furnace construction, the removal of the box-tile from the tubes in front of the bridge-wall, and thickening the fire to seven inches.

Figures No. 16 and 17 shows the furnace construction recommended. It consisted of a baffle-wall in rear of the bridge-wall having two arched openings. The arches were sprung from a central pier to the side walls of the setting,

the distance from the crown of the arches to the box-tile being approximately 18 inches.

The purpose of this baffle-wall was three fold; to secure a more intimate mixture of air and gas, to produce a longer flame travel, and to interpose in the natural path of the flame a mass of brickwork which, due to its position would heat more rapidly than the walls of the setting.

The box-tile was removed from the tubes as far back as the bridge-wall, and T-tile substituted. This was thought advisable in order to prevent the furnace from attaining too high a temperature. Box-tile covered the tubes from the front face of the bridge-wall to the baffle-wall to prevent direct impingement of the flame upon the tubes with the attendant liability to blow-torch action.

The furnace of boiler No. 13 was the first reconstructed along these lines. The results of a test are shown in Figure No. 13.

In this test, a high CO_2 reading of 15 per cent and a low of 8½ per cent was secured, averaging 12½ per cent. This *average* is but one per cent less than the *highest* reading of all previous tests upon this furnace before reconstruction.

The most important point in the test is to be found in the Smoke Chart. Graded readings were made upon the stack, which, of course, gave the aggregate of smoke emitted from all the boilers. Observations were made through a peep-hole in the combustion chamber of the boiler under test. The peep-hole was located in the middle of the length of the first pass, about a foot below the first row of tubes. Although the stack emitted dense smoke for a large part of the observation, the gases in the combustion chamber of the test boiler were transparent, and the chamber so bright that the observer was able to see distinctly the brickwork of the opposite side wall, a distance of 9 ft., 6 in.

Figure No. 15 shows the results of a test upon boiler No. 8 after furnace reconstruction.

The high CO_2 reading was 16.3 per cent, the low 13.4 per cent, averaging 15.3 per cent.

During this test, inspection through hole No. 3 showed clear gases with but an occasional dash of flame. Holes No. 5 and 6 showed intensely white flame. The appearance of the entire combustion chamber indicated complete combustion.

During similar tests upon this furnace complete analyses were made when CO_2 readings of 16 per cent or above were obtained. In but one instance was a trace of CO found, the reading being less than 0.2 of one per cent.

It is worthy of note that an average of 15 per cent CO_2, when, as in this case, complete combustion is secured, is obtained with but 35 per cent excess air over the theoretical amount required.

The results obtained in this test are seldom equaled upon chain grate stokers in ordinary practice, and show the desirability of securing a thorough breaking up of stratification and mixing of gases in the combustion chamber.

[NOTE.—Further discussion of this paper is invited, to be received by Joseph W. Peters, 3817 Olive Street, St. Louis, for publication in a subsequent number of the JOURNAL.]

THE TWIN CITIES' INTEREST IN THE HIGH DAM.

By Adolf F. Meyer.*

[Read before the St. Paul Society of Civil Engineers].

The Twin Cities have a two-fold interest in what is popularly known as the "High Dam." They are interested in the improvement which this dam will effect in the navigation of the Mississippi River, and they are also interested in the High Dam as a source of a very substantial quantity of water power.

The extent to which the extension of the navigability of the Mississippi River from St. Paul to the easterly portion of Minneapolis will benefit these communities, no one can accurately foretell. It is not apparent, however, why the extension of the navigability of the river a few miles northwesterly should add greatly to the existing navigation on the river below St. Paul; why the mere fact that the river will be navigable to Minneapolis should result in a great revival of water transportation, notwithstanding the fact that there will be no substantial change in its navigability below St. Paul.

In considering the benefits which it is hoped will accrue to these communities as the result of this navigation improvement, it is well to keep in mind that water transportation is always handicapped because the service that it can render is necessarily intermittent and almost invariably uncertain. Our inland waterways of Minnesota are icebound for nearly half the time, and particularly during the greater portion of the crop-moving period. Moreover, waterways are fixed in location, and incapable of material extension, when compared with our railway systems, whose tracks can reach every village and every factory. Waterways are usually unnavigable at the time of greatest demand for transportation facilities, hence they necessitate, in a large measure, a duplication of transportation equipment. In comparing rail and water rates, it is common practice to compare these rates on the basis, merely, of cost to shipper. We deceive ourselves into believing that Uncle Sam builds the waterways; that if a boat can move freight at a lower rate than a railway train, the community benefits from the water transportation. As a matter of fact, every community in the United States pays

*Consulting Engineer and Associate Professor of Hydraulics, University of Minnesota.

its part of the river improvement now being executed in the Twin Cities by the Federal Government, and we, in turn, contribute toward every improvement carried on between the Atlantic and the Pacific, and between the Gulf and the Great Lakes. In other words, this community and its tributary area which is to benefit most from the work under discussion, virtually pays for its own river improvements. To be of benefit to this community then, our waterways must permit the carrying of freight at rates sufficiently low to pay not only the mere cost of operation, but also the fixed charges on the money invested in the improvement. As actual or potential competitors of our railways to keep down rates, waterways have virtually been displaced by Rate Commissions. Unless our waterways can render real service to the community, and fully repay us for the money spent in their improvement, they cannot be considered the important factors in our commercial development that some of our waterway enthusiasts would have us believe.

Since our waterways are not available at the time of greatest demand and must be practically duplicated in rail equipment which, by itself, is capable of meeting the maximum demand for transportation facilities, the fixed rate charges plus the operating cost of our waterways, must be less than the cost of operating our railways, exclusive of fixed charges on the structures and equipment, or our waterways will not effect a saving from the social viewpoint. The desirability of river improvement must, after all, be measured, primarily, by the return which we will get for every dollar invested. A few of our main, direct waterways, requiring little improvement per mile of route, such as our Great Lakes System, are yielding a splendid return to the country on the money spent on their improvement. The benefits resulting from the improvement of our minor, circuitous waterways, however, is not so evident.

While the Twin Cities, through the aid of their Congressmen, were able to secure the expenditure of over $2,000,000 on this portion of the Mississippi River as their share of river and harbor appropriations, I venture the statement, predicated upon a judicious use of the energy which will become available, that the High Dam possesses at least as great potential value for the power which it will develop, as for the service

which it will render the country in improved transportation facilities.

The interest of the Twin Cities in the High Dam as a source of water power, is primarily the interest of the consumer in securing a necessary article of consumption at a lower price. In the disposition of power developed at the High Dam, three possibilities are worthy of consideration:

First, the Federal Government may complete the development, install the necessary hydraulic and electrical equipment, and operate the plant,—disposing of the product in the open market.

Second, the Government may lease the site and the power house, in its present state of partial completion, to the highest bidder.

Third, the Federal Government may lease the site to the Twin Cities and the State of Minnesota, as represented by the Municipal Electric Company.

In case the Federal Government completed and operated the power plant and turned the surplus earnings of the plant into the Treasury of the United States, it would mean a saving to the tax payers of every *other* portion of the country. However, assuming a fairly uniform distribution of river improvements throughout the country, this community, and its tributary area, as previously indicated, has virtually paid for its own river improvement. It would appear then, that it is entitled to at least a large share of the benefits resulting from the improvement, consequently, the earnings of the plant, over and above the fixed charges and cost of operation, properly belong to the community. If such surplus earnings were returned to the State of Minnesota, as represented by the State University and Cities of St. Paul and Minneapolis, in return for furnishing the Federal Government with flowage over their lands, and for relinquishing all claim to the appurtenant fall which makes the development of power at the High Dam commercially feasible, and also, in consideration of the fact, as previously indicated, that each community virtually pays for its own river improvement,—under these conditions there would appear to be no objection to the Federal Government developing the water power and selling the product in the open market.

In discussing the second possibility, i. e., of the Federal

Government leasing the power site to the highest bidder, it is necessary to consider the mutual obligations which have been incurred from time to time between the Federal Government on the one hand, and the Twin Cities on the other.

In furthering the navigation improvement, the Cities have donated part of the site for the present High Dam, and have dealt liberally with the Federal Government in the matter of granting flowage over lands lying above the ordinary high water mark. On the other hand, in urging upon the Federal Government desirability of modifying the original project to provide for the development of water power, both St. Paul and Minneapolis pledged themselves to pay for the additional cost, then estimated as about $250,000, of increasing the height of the dam so as to make the development of water power possible.

The original project called for the construction of two navigable dams. At neither of these dams, however, was sufficient fall available to make the development of water power commercially profitable. This matter was reported upon, in no uncertain terms, by a Special Board of the United States Army Engineers, in 1907. All of the land over which the Federal Government can be considered as holding an easement in the public interest had already been utilized for navigation purposes. When negotiations for the modification of the navigation project to provide for the development of water power were initiated, riparian ownership in practically all of the additional land required for flowage, amounting to about 40 acres of fast land above the high water mark, rested in the State of Minnesota and in the Cities of St. Paul and Minneapolis.

In adopting the recommendations of the Chief of Engineers for the modification of the original navigation project to provide for the development of water power, Congress did not say, in so many terms, that the High Dam was *necessary* for navigation purposes. The circumstances surrounding the case of the Twin Cities are widely different from those which led up to the Chandler-Dunbar decision in the St. Mary's Falls case. In that instance, Congress on March 3, 1909, declared by legislative enactment, "That the ownership *in fee simple absolute* by the United States of all lands and property of

every kind and description north of the present Saint Mary's Falls ship canal, through its entire length, and lying between the said ship canal and the international boundary line at Sault Sainte Marie, in the State of Michigan, *is necessary for the purpose of navigation of said waters and the waters connected therewith*." (Italics are writer's own.)

The Secretary of War was directed to take proceedings, immediately, for the acquisition, by condemnation or otherwise, of all of said lands and property of every kind and description, in fee simple absolute.

In the case of the High Dam, on the other hand, the Second Special Board of Army Engineers reported favorably on a proposed modification of the navigation project to permit the development of water power. It believed co-operation with the Cities of St. Paul and Minneapolis to be advisable. The Board of Engineers for Rivers and Harbors concurred in the recommendations and conclusions of the Special Board. The Chief of Engineers also concurred in the recommendations of the Board, and expressed himself on the proposed co-operation in these terms:

> The Cities of Minneapolis and St. Paul are deeply interested in the construction of a high lock and dam, and in addition are naturally *the most desirable lessees* of any surplus power that may be created thereby. Through assurances of reasonable and proper concessions to them in the matter of leasing such surplus power it is thought to be possible to secure a voluntary donation of the right of flowage over their lands. It is therefore recommended that negotiations to this end be had with the proper agencies of these municipalities . . . . . ."

In the River and Harbor Act of June 25, 1910, Congress adopted the modified project as recommended by the Chief of Engineers, with the provision, "That in the making of leases for water power, a reasonable compensation shall be secured to the United States, and the rates as fixed shall be subject to revision by Congress."

Hence Congress also expressed itself as being favorable to the lease of the available water power to the Cities of Minneapolis and St. Paul, with merely one provision, namely, that a reasonable compensation be secured to the United

States and that the rates as fixed be subject to revision by Congress.

Congress adopted the recommendations of the Chief of Engineers to the effect that negotiations be had with the municipalities for the purpose of securing free flowage over their lands in consideration for assurances of reasonable and proper concessions to them in the matter of leasing the surplus power.

It would appear then, that not only the War Department, but the Congress of the United States, has committed itself in favor of leasing the available power to the Twin Cities and the State University, at a reasonable rate, in return for obtaining flowage over their lands at nominal cost. It then, instead of leasing the available power to the Municipal Electric Company, the Federal Government offered the lease to the highest bidder, it would appear that the Cities of St. Paul and Minneapolis and the State University, in receiving compensation for their riparian rights, would be entitled to all that the raw water power is worth for commercial purposes. The Government would be taking from the Twin Cities not only 40 acres of fast land, but the appurtenant fall which makes power development at the High Dam commercially practicable. Although technically, the Cities and the State University may be considered as separately owning certain parcels of land, the fall along which does not permit of economical development, and although at about the time that I reported upon the advisability of the State University, as a member of the Municipal Electric Company, entering into an agreement with the Federal Government for the leasing of the power site on the terms of the Stevens' Bill, then before Congress, I urged that if the Municipal Electric Company were forced to bargain with the Federal Government, it would be in a stronger position if the Cities and the University pooled their rights and deeded all of the flowage lands to the Company; nevertheless, from the broader, moral viewpoint, I believe that no action on the part of either city in parting with valuable riparian rights, should invalidate the larger claims for consideration which the Cities and the University have, because of their former ownership of practically all of the fall in the river which makes the High Dam valuable as a power site. I would repeat, then, that if the Federal Government desires to lease the power site

to the highest bidder, the Twin Cities and the State are entitled to virtually all that the raw power is worth in the open market.

In the event of actual competition in bidding, and in the event that the Cities and the State received for their riparian rights all that these rights are worth, the community would receive substantially all of the benefit to which it can lay claim. On the other hand, if the power were sold to a private corporation under the competitive bids, and if the Cities received little or nothing for their riparian rights, the community would receive neither direct compensation for valuable water power rights, nor indirect compensation in reduced rates, unless the highest bid was substantially less than the value of the power rights secured, and unless the successful bidder happened to be a public service corporation, operating as a monopoly, and whose rates were subject to regulation by a public body.

If the rights are to be sold to the highest bidder, the Municipal Electric Company is, of course, free to bid. If we admit that this Company would be unable to compete with public service corporations for the power rights, we virtually admit that the Municipal Electric Company is not in a position to utilize the available power to as good advantage as the public service corporations which already have an established business. Unless the Municipal Electric Company can market its product without restriction, this is undoubtedly true, notwithstanding the fact that in some respects the Cities have an advantage over the private corporations. They can borrow money at a little lower rate of interest, and sell bonds for a longer term of years. They are not suffering from overcapitalization, and are not burdened with undesirable contracts or obsolete equipment. They need not spend money on rate controversies or litigation, nor incur development expenses. Moreover, the existing pumping plants of the two Cities can be utilized so as to reduce the necessary investment in a steam auxiliary power plant by about $200,000. This pumping plant can deliver water to the reservoirs of the cities at a less operating cost than a small steam power plant generating current which has to be transmitted and transformed, and then applied through a motor to centrifugal pumps, can possibly do. As the steam pumping plants are in

existence, they serve as emergency pumping equipment and auxiliary power plant of about 2,500 to 3,000 kilowatt capacity at the same time.

The reservoir storage at the Minneapolis filtration plant amounts to about 80,000,000 gallons. By 1920, the daily water consumption in winter is not likely to exceed 40,000,000 gallons. The Minneapolis steam pumps have a capacity of 30,000,000 gallons daily, so that in case the electrical pumps were temporarily disabled, or no current were available, the steam pumps, by running continually, would be able to furnish the additional water necessary to supply the city for eight days. The St. Paul steam pumps have an aggregate capactiy of about twice the present mean daily water consumption.

On the other hand, there appears to be no valid reason why, through proper co-operation, current might not be secured from public service corporations for the operation of motor driven centrifugal pumps during off-peak hours, as is now done in Minneapolis, and the steam pumps of both Cities operated at times of low water, exactly as if the Municipal Electric Company were furnishing the current.

To be able to bid against public service corporations for the power rights at High Dam, the Municipal Electric Company must be in a position to dispose of its product in the open market, and without restrictions.

In the event of the third possibility, i. e., that the Federal Government would lease the power rights to the Municipal Electric Company on terms substantially in accord with the promises of the two Cities to pay the increased cost of the High Dam, and in accord with the recommendations of the Chief of Engineers and the Act of Congress, which recognized the two Cities as "the most desirable lessees of the surplus power," the Municipal Electric Company would be in a position to furnish current at attractive rates.

In 1913, the Government Engineers estimated the additional cost of the modified navigation project, to make water power available, as being $800,000; including in this estimate $180,000 for flowage rights over both private and city lands. Adding to this original estimate the probably increased cost occasioned by delays and washouts during the past two years, and the cost of completing and equipping the power house, the cost of transmission lines and substations, but not the

cost of the distribution system required to bring the power to the various points of consumption, such as the street lamps, for example, and then deducting the estimate for flowage over city and state lands, will bring the probable total cost of power development at the High Dam, upon which a return must be earned, to nearly $2,000,000. Although interest and depreciation charges on a large portion of this investment would be relatively small, it is probable that not less than an annual return of $200,000 will be required to fully pay all fixed charges and operating costs on the power plant, transmission lines, and substations. On the basis of the last ten years' records, there would be an average of 9,000 kilowatts of power available at the station switchboard. This would represent an average of about 67,000,000 kilowatt-hours of power at the various substations which, if all utilized, would need to bring an average of three-tenths of a cent per kilowatt-hour at the substation in order to yield an annual return equivalent to the above estimated fixed charges and operating costs.

The feasibility of the Municipal Electric Company operating a power plant at the High Dam would depend primarily upon the amount and the character of the load which the demands of the Cities and the State University would place upon the plant. If the interests of the Twin Cities are to be served, it is imperative that a definite plan for the utilization of the available power be mapped out before the Municipal Electric Company bids for the power rights at the High Dam. I would judge from the position which some people have taken in this matter, that they are in favor of securing the power rights at the High Dam and then selling them to the highest bidder. That may be a feasible plan if the power rights can be secured from the Government with such disposition in view! On the other hand, however, it is possible that public utility corporations would be inclined to bid for the power just about what they felt it was worth to the Municipal Electric Company, in case that Company desired to develop and distribute electrical energy to the Cities and to the State University. In the last analysis, then, the desirability of obtaining the power rights at the High Dam would seem to be dependent, largely, upon the uses which the Cities and the State University can make of the power which would become available.

Among the principal public purposes for which power could be used are street lighting, pumping of water, and the miscellaneous light and power uses at the State University. While the present demands for these purposes, measured at the station, amount to less than half the average available power, these demands are somewhat greater than the power available during a few days of the winter extreme low water period. These demands are continually increasing, and auxiliary power from some other source will very soon be required even if the steam pumps are operated as an auxiliary during occasional extreme low water periods. If each one of the three members of the Municipal Electric Company proposes to install and operate an independent steam auxiliary, these plants will be so small and uneconomical as to be incapable of developing power at a cost at all comparable with that at which the larger steam units of the public service corporations can develop power. If the Twin Cities want the High Dam power, not only must a definite load be mapped out for the plant, but a definite agreement must be reached with respect to the provision of a steam auxiliary plant. If the Cities object to the purchase of auxiliary power from public service corporations and demand an independent steam power plant, then this plant should be centrally located and should furnish power for all three members of the corporation.

On the whole, street lighting and pumping make a very satisfactory load. Neither pumping nor street lighting load, have, strictly speaking, a peak. Both are really uniform loads extending over a varying number of hours. While the greatest demand for light occurs in winter, the greatest demand for water occurs in summer, so that the combination of the two makes a much better load than either alone. The light consumption in winter is about one and one-half times what it is in summer. The water consumption in summer is about one and one-half times what it is in winter.

If the present gas and gasoline lights are replaced by electric lights, the street lighting and pumping loads will, in a few years, be practically equal, making a splendid combined load of sufficient size so that no miscellaneous light and power load that may be added can produce a high sharp peak. The result is a load factor very much better than that of the ordinary commercial light and power loads.

So far as the utilization of electrical energy, developed at the High Dam, is concerned, there seem to be no serious obstacles to prevent its use for street lighting and for pumping purposes by the municipalities. Pumping in St. Paul is at present done by steam, consequently the change to motor driven pumps can conveniently be made at any time. In Minneapolis, most of the pumping is being done by motor driven pumps with current furnished by the Minneapolis General Electric Company, but under a contract which is terminable within six months. Street lighting in St. Paul and Minneapolis is done by public service corporations under a one year contract.

According to Judge Fish, City Attorney, Minneapolis has the necessary authority to purchase such existing street lamps, poles, wires, and other appliances connected with the present street lighting installation as it may desire to use, in the event it should do its own street lighting. The Police and Fire Departments now have the right to use certain ducts and poles. It is customary now, according to the Minneapolis Gas Inspector, Mr. Meeds, for the companies to make joint attachments to poles wherever possible.

In the franchises of the St. Paul Gas Light Company, and the Consumers Power Company, according to the Corporation Attorney of St. Paul, the right is retained by the City of granting to any other companies, the right to use the poles and wires of said electric companies upon paying a pro rata share of the cost of construction and maintenance.

The Corporation Attorney holds, further, that there is a provision in those franchises that in case the City should build and maintain conduits of its own of sufficient capacity, it could order in the wires of the two companies mentioned, and compel them to pay a fair rental for the use and maintenance of the city conduits.

The amount of current furnished at present for street lighting purposes, from underground circuits, is comparatively small in proportion to the total amount of current that will be required for such purposes in a very few years. Moreover, it would seem entirely practicable for the cities to feed their current into the substations of the public service corporations, in the down town districts where the lights are connected in multiple to the underground commercial circuits,

and to pay these corporations a fair rental for the use of their conduits and circuits.

It is safe to say that if cheap current can be secured, both cities will find it desirable to gradually replace their gas and gasoline lights with electric lights. In the residence portions of the cities, pole lines are desirable. In some portions of the Cities these lines have been placed in the alleys. In other portions they have been placed on the cross streets. As the residence portions become more closely built up, it will no doubt become desirable to lay conduits in these portions and to require all telephone wires and light wires to be placed underground.

So far as extensions and alterations to the present systems are concerned,—and these constitute the major portion of the street lighting systems of the two Cities, when one looks at this problem in a broad way—it would appear that the Cities are in a position to make these extensions at least as advantageously, if not more so, than a private corporation. A fair rental can be charged the public service corporations for the use of the Cities' pole lines and conduits, and the arrangement made mutually advantageous and a benefit to the public.

On the other hand, in order to utilize the power available at the High Dam to best advantage, the Municipal Electric Company should be in a position to dispose of surplus power, available only at certain seasons of the year, in the open market. Furthermore, it should be in a position to purchase current produced by existing steam plants whenever such purchases appear desirable and economical. In other words, to secure the best service for the community, not only the High Dam but all other water power plants furnishing current to Twin Cities consumers, should be interlocked with existing steam plants into an interdependent system. True conservation demands that all of the water power plants should operate at as near to 100 per cent load factor as possible, and that so long as water is available no water power plants should be idle while steam plants are in operation. Steam plants should be used primarily as reserve equipment during low water seasons, and as insurance against interruptions in service due to break-downs in the water power plants.

In conclusion I desire again to call attention very briefly to the water power which will become available, and to what

I believe to be the value of the High Dam as a power site to any corporation developing power by steam.

On the basis of the past ten years' records of stream flow, there will be an average of 9,000 kilowatts or 78,700,000 kilowatt-hours of power available at the station switchboard. During the lowest month of the driest year, there will be an average of 4,000 kilowatts available, and during the most extremely cold days of mid-winter there may occasionally be not more than 3,100 kilowatts available for a few days, even when the pool is used to best advantage. At times of low water the existing pumping plants of the two Cities could economically be operated so as to raise the minimum available power to about 6,000 kilowatts.

The water requirements of the Government Lock have, at times in the past, been grossly exaggerated. In the first place, the demand of water for lockage purposes occurs during the open season, and not at the time of maximum demand for power, nor at the time of minimum stream flow. Furthermore, if 25 boats were locked through every day, one at a time, only about 250 c. f. s. would be required for lockage purposes. This would probably reduce the average power available per annum by less than one per cent. Even assuming that navigation increased to such an extent that boats would be waiting in line to be locked through, and that the Government machinery operated as fast as possible, day and night and every day during the summer, the maximum demand for lockage purposes would not exceed about 400 c. f. s. Moreover, if navigation increased to such an extent as to demand even these 400 c. f. s. during the summer months the community would be benefited by several times the cost of producing the equivalent amount of power by a steam plant during these few summer months when there is not an excess of water. The Government demands for water for lockage purposes, then, may be dismissed from consideration.

The hydro-electric installation contemplated in the report which the writer made to the University about two years ago consists of four units having a normal capacity of 10,500 kilowatts, and an overload capacity of 12,500 kilowatts, when utilizing 6,000 c. f. s. under a 34 foot head. While the average amount of water power available during the winter months will not much exceed 4,000 kilowatts, it does not follow that the difference

between 12,500 kilowatts and 4,000 kilowatts must be supplied by steam in order to carry a peak load of 12,500 kilowatts. At times of maximum demand, during the winter months, whenever the stream flow falls below 4,500 c. f. s., the pool above the dam can be utilized and the water power plant operated at a reduced load factor. In this way the steam auxiliary plant may be operated at an increased load factor, so as to materially reduce the size of the required steam plant for any given December peak load. On the other hand, the contemplated installation would be capable of carrying a flood water peak load of only 7,000 kilowatts, i. e., the size of the required auxiliary steam plant may possibly depend upon the June peak load. A 5,000 kilowatt steam plant, operated in conjunction with the water power plant at the High Dam, would be able to carry a December peak of 15,000 kilowatts at a 60 per cent load factor, even though the average amount of water power available in December did not exceed 4,000 kilowatts. The same plants, however, would be able to carry a peak of only 12,000 kilowatts during extreme high water, but with 100 per cent load factor if necessary. The size of the steam auxiliary, then, may possibly be determined by the June peak load instead of by the December peak load, even though the latter may be much the larger, and the *average* amount of water power available in December may be much smaller than the *average* amount available in June.

These considerations all go to emphasize the fact that while the High Dam has indisputable value as a power site,—and there is nothing to be gained by minimizing its value in our efforts to secure the power rights for the Twin Cities and the University—it does not necessarily follow that its value may not be totally destroyed by unintelligent attempts at the utilization of the energy which can economically be developed at that site.

It has always been my view that the High Dam is of value to the Twin Cities primarily as a nucleus around which a municipal electric light and power plant may be built. If the Cities acquire the power rights at the High Dam but are averse to further ownership and operation of public utilities, these power rights would appear to be worth, to the Cities, whatever public service corporations are willing to pay for them, minus what it will cost the Municipal Electric Company to acquire these rights from the Federal Government.

[NOTE—Further discussion of this paper is invited, to be received by Joseph W. Peters, 3817 Olive Street, St. Louis, for publication in a subsequent number of the JOURNAL.]

RIVER TERMINALS AND A BOULEVARD SYSTEM FOR ST. LOUIS

By Julius Pitzman,
Member of the Engineers' Club of St. Louis.

An address delivered before a public meeting of the City Plan Commission on October 26, 1915.

Gentlemen of the City Plan Commission:

At the request of the President of the Engineers' Club I appear before your Honorable Body to give my views on the subject of *Defects in the present System of the Development of our City* and also to suggest remedies for such defects.

In speaking on this subject, however, I wish to say that any statement I may make simply represents my own views, as they are given without consultation with or the approval of the members of the Engineers' Club.

The principal defect in the management of public affairs, in my humble opinion, is to be attributed to the fact that the majority of men selected for the City Council, or the Municipal Assembly, have been men without sufficient experience in public affairs to cause plans to be made for the rational development of our City, and this system, or rather the want of a system, has been the cause of enormous pecuniary losses to our citizens and of the failure to realize all the advantages due to our splendid geographical location.

I came to St. Louis in 1854, at a time when the property on Fourth and Fifth streets between St. Charles street and Chouteau avenue was the fashionable district. Shortly thereafter Chouteau avenue took the lead. Then followed the districts between Market street and St. Charles street between Fifth and Twelfth streets, Lucas place between Fourteenth and Eighteenth streets, the Lafayette Park and Compton Hill districts and finally Stoddard addition, between Beaumont street and Garrison avenue was built up with elegant residences. As Stoddard addition was located upon a magnificent plateau and close to the business part of St. Louis, the people supposed that their investments were safe for a long period of years and began to build expensive homes. Street railroads and rapid transit facilities, however, caused great changes and in consequence thereof the younger generations bought

lands further out, the electric line followed or preceded them in all directions and caused the City to spread rapidly.

The city administration has never attempted to regulate the growth of the city, never has developed a general plan and in consequence of its failure to do so, districts undesirable for homes and beyond reasonable extended limits were built up and enormous expenditures were required to provide streets, water, gas, sewers, etc., through vacant tracts to reach these scattered districts. This method of expansion not only largely increased the expenses of the City for maintenance, but also forced the companies furnishing gas, electricity and transportation to make larger charges than would have been necessary if the City had been developed under a well prepared plan and had not been permitted to scatter over too large a district.

Most of you gentlemen have seen how rapidly such districts in the West End, as the Grand avenue, Sarah street and Taylor avenue ridges, were built up with elegant homes and how rapidly they decreased in value, simply because land beyond the improved district could be bought for a lower price. This process has been going on so rapidly that in a few years many of our wealthy people may live in St. Louis county and the cost of maintenance of the City will have to be borne by the business men and by the poor and middle classes which may retain their homes in St. Louis. By an intelligent management, these conditions could have been avoided to a large extent, by simply reducing the railroad fare in the old portion of the city, say to three cents, and by charging one cent additional for each mile beyond those limits or by not granting franchises through districts which should not be subdivided on account of the cost of procuring drainage, etc., for such localities. If, at the time street railroads were started, authority had been given to experts to lay out certain routes with the view of developing the city systematically, and if companies wishing to build railroads would have been obliged to build the roads along the routes designated, then the city would have been much more condensed, the cost of building streets, sewers, etc., would have been lower and the railroad fares could have been reduced without loss to the railroad companies.

Streets and Sewers.

I have, for many years, criticised the action of our city administration for building streets and sewers in outlying districts under the special tax law, for the reason that, in many cases, the levy of taxes amounted to confiscation and because an enormous amount of land was forced on the market which should have been used for truck gardening for many years to come and for the further reason that it was not a benefit but a serious injury to our city.

The land within the boundaries of St. Louis contains about forty thousand acres and if all the land is subdivided, it would be sufficient to provide homes for a population of two and one half million people and as we only have about three-quarters of a million inhabitants, it is unwise and a great injustice to the owners of property to build such improvements under the special tax law .

The deplorable condition of property on Olive street between Eighteenth street and Grand avenue or Taylor avenue is the best illustration and proof of the mistakes made.

In most European cities, the cost of streets and sewers is paid by a bond issue and the owners of lots pay their proportionate part of the cost as soon as they improve their property, but no person is permitted to build large dwellings, etc., except in districts provided with sewers, and I would consider it a great benefit if the legislature of Missouri could be induced to pass a law to prevent nuisances by providing that not more than one dwelling can be erected on an acre of land unless sewers, septic tanks or filter beds are provided.

The subject under consideration is so complicated and requires such careful consideration that the short time allotted to each speaker to-night is not sufficient to go into further details and I therefore take the rest of the time allotted to me to give my views on plans for the future development of St. Louis.

River Terminals.

When I arrived in this city, sixty-one years ago, a line of steamboats and barges, three abreast, were laying in the harbor between Wash and Plum streets and the entire levee for a width of about one hundred feet was covered every after-

noon with goods to leave by boat at four o'clock. All the goods being exposed to view, its vastness made a great impression upon visitors.

The sloping wharf, 180 feet in width, extending from high to low water, has rendered splendid service in our early days, but it is almost useless at the present time and rather impedes than facilitates commerce.

Lots along the levee, in the central part of the City, when I came here, sold for over a thousand dollars per foot and I do not think that they produce to-day one tenth of the former income. As the property north of Franklin avenue and south of Plum street sells at much higher prices than the land in the central portion of St. Louis, it shows conclusively that we have not made proper use either of Front street and the wharf nor of the abutting property. *To procure river and railroad traffic,* I beg leave to suggest the condemnation of all property between Commercial alley and Front street, between Biddle and Plum street, and its improvement by building a street at an elevation of about twelve feet below the grade of Main street and from the western line of Commercial alley eastwardly one hundred and fifty feet and the building of a retaining wall along the river and public warehouses, railroad yards, etc., extending from the 150 foot street eastwardly 150 feet to the retaining wall. I think it necessary to condemn the lots between Front street and Commercial alley in order to procure the unrestricted use of Front street and the wharf and for the reason that every foot of the property is required for the purposes mentioned.

As the Terminal Railroad has built an elevated track along the levee, the City should assign to said company in lieu thereof, a right of way in the center of the projected road and build streets and tracks on each side thereof with switches leading into the warehouses fronting on the river and into the basements of the main street stores.

The improvement of the river and railroad terminals would do as much for the building up of St. Louis, in my opinion as the construction of the quays, docks and harbor improvements of Liverpool and Hamburg did for those two cities. The City of Liverpool was authorized under one Act of Parliament to issue bonds for

thirty million pounds, or one hundred and fifty million dollars, for the projected work and a tax was levied on all goods shipped by way of Liverpool to cover the interest and maintenance. The City then built the docks, quays, warehouses and floating wharves used for the landing of the passenger steamers on property covering over a thousand acres and these splendid improvements brought the commerce of the world to Liverpool and after thirty years the income derived therefrom had exceeded their expectations to such an extent that new works were built out of the accumulations.

At the time Liverpool built these works, the commerce of Hamburg was comparatively small, but its City government followed the example of Liverpool and spent enormous sums of money for not only building wharves, warehouses, etc., in Hamburg, but they also dredged the River to Altona, the estuary of the North Sea, built there immense warehouses for the use of steamers drawing over thirty feet of water, and established direct connections from Altona with all railroads leading into the interior of Germany. For a long term of years, the expenditure of Hamburg for harbor and river improvements has been over seven million dollars a year and the expenditure has made Hamburg, next to New York, the greatest shipping center of the world.

The City of St. Louis, under its agreement with the Terminal Railroad Association, has acquired the railroad built by the Wiggins Ferry Company along the river front, extending from Arsenal street northwardly to Grand avenue and connecting with the City's railroad at the Chain of Rocks, and this road should, in my opinion, be extended southwardly to the River Des Peres and then developed by building switches wherever required leading to the factories, etc. The City will then own a railroad eighteen miles in length, extending from the Chain of Rocks to the River Des Peres and having acquired and developed it, at a trifling cost, the City can offer to lease it to a railroad company under a contract regulating charges at such a low figure that our merchants and manufacturers can easily compete in the world's markets and in less than thirty years this road will probably be one of the most valuable roads per mile in this country and would be the greatest factor in the development of the commerce of St. Louis.

The Manufacturing District.

After the railroad is established, the entire district between Fourth street and the river would probably be utilized for the expansion of the manufacturing and wholesale business and the City would then be justified in refusing the erection of factories outside of said district or of other railroad zones.

While considering the treatment of the river front, I wish to say that I consider the development of the property on the Illinois side of paramount importance and that I consider it a short-sighted policy to antagonize our neighbors across the river.

St. Louis will never be a great City unless it makes proper use of the river and of the land on both sides thereof. If you examine the topography of large European cities, you will find that London is divided by the Thames, Paris by the Seine, Liverpool and Manchester by the Dempsey, Vienna by the Danube and Berlin by the Spree, and in every instance the manufacturers or the homes of their employees are on one side of the river and the merchants and wealthy people on the other.

The great advantage that East St. Louis has is cheap coal and cheap land.

A manufacturer in St. Louis who requires a block of ground with switching facilities will probably have to pay one hundred thousand dollars for the ground, then he has to erect a substantial shop in conformity with the rules and regulations of the Building Commissioner, costing from fifty to one hundred thousand dollars, and if he is successful he needs more land for expansion; after a term of years he may have to abandon his place because he cannot purchase adjacent property or vacate the adjacent streets. In East St. Louis or its suburbs, a manufacturer can buy lands with switching facilities at one or two thousand dollars per acre; he can therefore afford to buy a ten acre tract, build a shop on an acre tract and enlarge from time to time; and he can obtain his fuel at a lower rate. It is, therefore, natural that many manufacturers who require large tracts of land find it to their interests to locate on the East Side, because the price of lands in near-by districts is prohibitive in St. Louis. As these men, however, do most of their banking and they and

their employees make most of their purchases in St. Louis, we should treat them well and encourage them in their undertakings.

The ideal development of the river terminals should include the construction of perpendicular walls on both sides of the river, with warehouses and factories built above high water line and with basement floors beneath, to be used during the low stages of the river, and the introduction and use of a large number of small boats or barges to carry freight to and from warehouses, factories and railroad terminals on both sides of the river.

A Boulevard System.

As most of our boulevards or places in St. Louis have been designed and built under my supervision, I naturally take great interest in the problems under consideration and I have made a careful study of European cities and boulevards. Last year when your predecessors recommended the ordinance for the Market street boulevard, I went before the Board, asked them to reconsider their action and gave the following reasons for my objections:

First, Market street is the first through street North of the railroad yards and of a district covered with warehouses, factories and of old dilapidated dwellings, occupied by a poor class of laborers and, therefore, Market street, even if widened into a boulevard, will remain a street for small shops.

Second, the contemplated boulevard, 280 feet wide, is entirely too wide for business purposes, because every close observer must know that business shuns wide streets.

Third, as only a limited amount of business is done on Chestnut street, Pine street and Olive street, between Eighteenth street and Grand avenue, it cannot be expected that the projected boulevard could be built up with business houses, and as there is a tendency for investors to build apartment houses in the outlying districts, it cannot be expected that they will risk their money by building them on the projected boulevard.

Fourth, as the old houses on both fronts of the projected boulevard would remain standing and as most lots fronting thereon are owned by men of limited means, very few prop-

erty owners would venture to erect buildings suitable for a pretentious boulevard.

Fifth, it being questionable whether or not the abutting property would enhance in value by the construction of the boulevard, and as everybody knows that its supporters considered its establishment a great benefit to the City at large, the cost thereof should be borne to a very large extent by the City under a bond issue and no attempt should be made to assess very large benefits on the property abutting or on the near-by districts.

Many of the people who advocated the adoption of the scheme had probably seen European boulevards, but I do not think that they took into consideration the fact that over half a million of the better class of people who frequent such boulevards live within a mile thereof and that the governments of England, France, Germany and Austria have spent millions and millions of dollars for the erection of palaces, museums, etc., to make them attractive. As St. Louis is not a seat of government and cannot induce the government to erect monumental buildings, I would suggest advancing on different lines.

The New Charter gives us the right of excess condemnation and I would suggest making plans to proceed under those provisions. Supposing your Honorable Body would recommend the condemnation of 109 feet on each side of Pine street, or of Olive street, between Twelfth street and Jefferson avenue or Grand avenue, then the title to such strip of land, 308 feet wide inclusive of Pine or Olive street and of both alleys, would be vested in the City, and if you would further recommend to set aside for Pine or Olive street, 108 feet through the center, to lay out lots, seventy feet deep, on each side thereof and a thirty foot street in the rear of the seventy foot lots, then you have an opportunity to build an attractive street or business boulevard. Of course, your recommendation would have to include the land from Eighteenth to Twentieth street from the Union Station to the one hundred and eight foot street. Such a plan would necessitate the acquisition and removal of every building on the projected boulevard, the construction of the streets at public expense and the holding of the lots until they can be sold or be disposed of by long

leases. To insure favorable results, the lots must be sold under restrictions and it might be found to be advisable to provide that no building should be put up in excess of a certain heighth of say four stories. For retail business, restaurants, hotels, etc., property seventy feet in depth, extending from the boulevard to a thirty foot street, is ample and most desirable and if no unsightly sky scrapers are permitted to be built, I think that such a street would build up very rapidly and be a great advertisement for St. Louis.

Every person who has knowledge of real estate values must know that the lots on Pine and Olive streets, west of Twelfth street, with the exception of the Eighteenth street district, are of comparatively low value and that the property has no future unless the old buildings are torn down and new uses are found for the property.

If the City acquires the property by condemnation and under bond issue, it can borrow the money at a very low rate of interest, it has no taxes to pay and as the large number of people whose lands are taken, have to find other property, the condemnation will cause property north and south of the projected street to rise in value and the City becomes the beneficiary by an increase of taxes.

I would like to speak to you concerning the establishment of boulevards in the outlying districts, but the time allowed does not permit me to do so.

The propositions submitted require very large sums of money and in order to procure them, it will be necessary to procure the passage of constitutional amendments. In order to obtain favorable action by the Legislature, I would suggest having complete estimates made of the probable cost of all the work that you may conclude to recommend, without pointing out which should be done first, and after the City has been granted the right to issue bonds for any of the purposes enumerated, then is the proper time to select such of the projects as will be of the greatest benefit to our City.

Twelve years ago, a commission consisting of George Leighton, John D. Davis and myself were appointed to submit plans for the establishment of the Kingshighway boulevard. The report was favorably received, and about a million dollars spent for its improvement, but the result has not

been satisfactory, because the administration has been dilatory in carrying it into effect, has made changes in the plans which were ill advised, and because the proceedings for opening several sections have been delayed by legal proceedings.

In order to see any of the above mentioned plans carried out, we must have new laws made to force prompt action by the Courts.

[NOTE.—Further discussion of this paper is invited, to be received by Joseph W. Peters, 3817 Olive Street, St. Louis, for publication in a subsequent number of the JOURNAL.]

OBITUARY

Robert Lee Kneedler

MEMBER OF THE ENGINEERS' CLUB OF ST. LOUIS.

Robert Lee Kneedler, whose death at Collinsville, Illinois, on the evening of September 30, due to electric shock, was born in Collinsville, on June 9, 1867. His education began when he was nine years of age in the country school at Collinsville, which he attended until 1880. He then spent four years in the high school at Collinsville and one year at Smith Academy, in St. Louis, preparing for the university. He entered Washington University in 1885 and took the five year course in Mining Engineering, receiving the degree of Mining Engineer in June, 1890.

After leaving the University he accepted the position of Mining Engineer with the Sligo Iron Company whose mine was located at Eden, Mo. Here he met and married Mary Jane McGinnis. Shortly after his marriage he moved back to Collinsville. For several years he was employed in railroad work and as Chemist for the Collinsville Zinc Company. In 1902, he was made Mining Engineer for the Donk Coal Company whose mines are located near Collinsville and remained with that company until his death.

He is survived by his parents, three brothers and one sister and his wife and six children.

Robert Lee Kneedler was a non-resident member of the Engineers' Club of St. Louis and also was a member of several fraternal organizations in his native town where he was known to the entire community.

He was very frank and straightforward in his manner and steady in his habits and enjoyed the confidence and respect of all who knew him.

JOHN J. LICHTER.

ASSOCIATION OF ENGINEERING SOCIETIES

ORGANIZED 1881.

Vol. 55. DECEMBER, 1915. No. 5

ASSOCIATION OF ENGINEERING SOCIETIES TO BE DISBANDED. FINAL REPORT OF THE CHAIRMAN.

During the year 1915 the Journal was issued regularly each month, except during July, when none was issued on account of a lack of material. The numbers compared favorably with those of recent years. Forty papers and reports were published, covering 540 pages, as compared with 36 papers and reports last year, covering 640 pages. These figures do not include the Proceedings, which are paged separately. Zinc plates and half-tones were freely used, the same as last year. Considering the reduced number of Societies in the Association, it is believed that the showing made by those remaining is very creditable.

When the Engineers' Club of St. Louis took charge of the publication of the Journal two years ago, the outlook for the Association was far from encouraging. The Boston Society of Civil Engineers had given notice of its intention to withdraw from the Association on December 31, 1913, and the Detroit and Oregon Societies of their intention to withdraw on March 31, 1914. The Utah Society had also voted in favor of withdrawing, but left the matter in the hands of a committee with power to act. It was hoped that the Societies of Detroit, Oregon and Utah might be prevailed upon to reconsider the matter and remain in the Association. In the case of Oregon and Utah our hopes were realized, but Detroit withdrew on March 31, 1914, as had been announced.

It was also hoped that by an energetic campaign of letter

writing new societies might be drawn into the Association to replete the severe losses occasioned by the withdrawal of the Boston Society with nearly 900 members and the Detroit Society with nearly 300 members. Here again we were destined to be disappointed. Encouraging letters were received from the officers and members of a number of societies, but when a vote was taken on the matter the motion was invariably lost. The inducements to join an organization which was apparently on the decline were not sufficient to overcome the inertia of the average engineering society.

On December 31, 1914, the Technical Society of the Pacific Coast became defunct and the Louisiana and Utah Societies withdrew to publish journals of their own. Correspondence with other societies which it was thought might be induced to join the Association was continued during the year 1915, but the results were barren, the number of prospects constantly dwindled, and during the last few months practically nothing has been done along this line. The Montana Society of Engineers withdrew on September 30, 1915, owing to the desire of a majority of its members to publish a journal of its own. During the last three months of the year the Association has therefore consisted of only three societies, viz., St. Louis, St. Paul and Oregon. The number of subscribers at present is approximately as follows:

St. Louis	415
St. Paul	77
Oregon	93
Independent	139
	724

Realizing that there was also considerable sentiment in these three societies toward withdrawing from the Association, the Chairman wrote to the officers of each society early in November making inquiries along these lines. The reply from the St. Paul Society stated that that society had already decided to withdraw at the end of the year. The Oregon and St. Louis Societies then took up the matter and decided to do likewise. All three societies agreed to the suggestion of the Chairman that the funds remaining on hand at the close of the year be divided pro rata according to the number of subscribers in each society. The bank balance, which amount-

ed to about $720, at the beginning of the year will probably be reduced to less than half of that amount after all obligations are paid.

The Journal of the Association of Engineering Societies, which was started in November, 1881, and which has been published continuously for more than 34 years, will cease with this issue. The primary object of the Journal was to furnish a medium for the joint publication of papers and proceedings of the associated societies. In this it has been eminently successful. It has been an important factor in maintaining high standards of professional thought and work. In affording to its members a ready means for the interchange of professional experience, practice and views, it has been of great interest and immeasurable value and in that way has been of greater and broader influence than the proceedings or actions of any one of its component societies could have been.

The disintegration and final dissolution of the Association is due primarily to the ambition of almost every society to publish a journal of its own. This is founded on sentiment rather than on logic, but it is a condition and not a theory, and it is useless now to discuss it. One society after another, as it considered itself strong enough to maintain a separate journal, withdrew from the Association, until finally the few who still believe in the principles of co-operation decided to give up the fight and yield to the popular clamor. The last three societies will now publish separate journals and place on the shoulders of the advertisers the responsibility for making up the financial deficit.

The December number is the 409th issue of the Journal and completes the 55th volume. Hundreds of libraries, societies, and individuals throughout the world have complete files bound for reference. Hundreds of others have files covering the time of their affiliation with the Association. Thousands of the leading engineers of the country, those who have wrought and written, have contributed papers of great interest and permanent value. The files of the Journal will be consulted for reference as long as libraries are maintained and engineers read and study.

It is with feelings of sincere regret that we close the final editorial and say "Farewell and Good-Bye."

JOHN W. WOERMANN, *Chairman.*

EQUITABLE SPECIFICATIONS AND CONTRACTS

By Hillis F. Hackedorn.*

[Read before the Engineers' Club of St. Louis and Associated Engineering Societies of St. Louis, December 1, 1915.]

It is difficult for me to express to you my full appreciation of the honor you have conferred upon me in inviting me here as your principal speaker for this meeting and I have serious doubts about my ability to measure up to the standards heretofore set by speakers before your organizations, but I will endeavor to give you some food for thought.

Of course you will realize that my viewpoint is bound to be that of the contractor, and my discussion of the subject Equitable Specifications and Contracts, will be entirely from that angle. I hope, however, that I may be able to treat the subject with fairness to the engineer as well as without prejudice to either.

It is indeed gratifying to witness the co-operation evidenced by the close fellowship so apparent in this organization composed of representatives of all of the engineering professions as well as representatives of those in the trenches—the contractors who bring to fruition the ideals and ideas of the engineers. It is a condition that should bring about a better understanding between the man who designs and the man who executes, which surely makes for better results in every way for the engineer, for the contractor and for the owner—the man who "pays the freight."

The St. Louis Branch of the American Society of Engineering Contractors, the National organization of which I have the honor to be president, has shown remarkable growth and prosperity. It is the prize branch of our national organization and we are indeed proud of it. Its members have demonstrated what can be done locally for the contractor and engineer by concerted, harmonious action, and we regret that we have not similarly successful branches in all of the principal cities of the country.

I can see great possibilities in the broadening and developing of the harmonious condition that exists here in your Engineers' Club and Associated Engineering Societies. Many of the worries and troubles of the engineer, as well as a majority of the misunderstandings between engineers and contractors, should be almost entirely eliminated by this close organization, looking

*President of the American Society of Engineering Contractors and President of the Hackedorn Contracting Co., Indianapolis, Ind.

to the interest not only of the engineer and contractor but also to the interest of the employer, the man who by his financial ability enables the engineer and contractor to keep busy. I do not know of another city in the United States where there seems to be the harmony of action that is so evidently present in your combined organizations here, and I trust that its example may be a directing force in the organization of many more such combinations.

The American Society of Engineering Contractors, ever since its organization in 1909, has had a number of ideals to which it has clung tenaciously. Of course, we realize that some of these ideals will probably never be realized within the life of the present generation, because they seem to be so far away from current practices, customs and beliefs. But there is one of our ideals which we of the present generation sincerely hope may be realized in all parts of the United States, and that is the idea of equitable specifications and contracts; specifications that are written fully and completely describing the work down to the minutest detail, eliminating all guesswork and conveying to the contractor completely the ideas of the engineer; describing fully what work he expects to do, how he expects to do it, sequence of the performance and the results he expects to obtain, leaving nothing for future argument, nothing for guesswork and nothing which may cause the contractor's scalp to be left dangling at the belt of the owner or engineer after the work is executed.

In reading over many specifications and contracts, it more than frequently occurs to me that the engineer who has written them seems to take the position that the contractor is bound to be a crook, ever ready to take advantage of the slightest point to put one over the engineer and owner. I want to go on record here and now with the statement that all contractors are not crooks, and it has been my pleasure during my experience of almost twenty years in the construction of reinforced concrete bridges, to meet a number of gentlemen in the contracting game, whose ideals and aims were as high and honorable as in any other industry, occupation, business or profession; likewise have I met contractors whose knowledge of the contracting business, and incidentally of the engineering profession, has been as broad, liberal and authentic as any engineer I have ever known, which leads me to believe that the engineering profession has no monopoly on knowledge and virtue.

The correction of the belief in the minds of college professors that contractors are all crooks, will go far toward eliminating that fallacy. Ninety per cent of these learned gentlemen in lecturing to their classes, teach and preach, continuously and repeatedly this sophistry. Of course, we must admit that there are in the ranks of the contractors some whose ideas of right and wrong are considerably stunted, but I do not believe that such men are as frequent as the college professors delight in preaching. This sort of teaching sends the young graduate out of the engineering schools with a narrow, suspicious viewpoint on life which is bound to handicap him, until he learns by experience that there are honest contractors as well as honest bankers, and if this error could be corrected, it would go a long ways towards bringing about a better mutual feeling between the engineer and the contractor. The ideal condition would be for the engineer and contractor to work earnestly and honestly to the common end of producing the very highest class of work at the lowest cost, including a reasonable profit for the contractor. This condition, of course, would eliminate all wrangling and misunderstanding between the engineer and contractor and would produce much more satisfactory results in every way for the owner.

One of the greatest impositions that is ever placed on the contractor is by the engineer whose specifications fairly teem with the expression "to the satisfaction of the engineer." This very-much-abused, never-understood, and impossible-to-forecast expression is about as serious a handicap as can be hung onto a contractor who is making up an estimate of cost on any type of construction. It leaves such a wide field for guesswork, it opens up such a broad avenue of opportunity for the engineer or inspector to "get even" with the contractor for some fancied or real grievance. It is something against which a contractor has no opportunity whatever to guard or protect himself, knowing as he does when he reads it, that nobody except God can tell what will satisfy the engineer, and the average contractor, not being on sufficiently intimate terms with the Deity to get any advance tips, must either guess at what will satisfy the engineer or trust to luck. I have seen many contractors practically ruined in an effort to satisfy an engineer who was unreasonable, but who nevertheless was backed by brass bound specifications containing this damnable clause.

This phrase impresses the contractor as an evidence of either

lack of knowledge on the part of the engineer or laziness in preparation of the specifications, and in many instances the contractor views these clauses in the light of a club to be held over his head during the construction of the work. They impress him with the belief that the engineer *thinks* he wants certain things done but if the contractor learns during construction that the engineer wants something else done, the contractor must be the goat and pay for the change. The engineer should be sufficiently advised and have sufficient knowledge of all conditions surrounding the work to enable him to make up a correct detailed guaranteed design and estimate. He should have the nerve to stand pat on his estimate and likewise should not expect the contractor to make good the cost of any mistake he may make in the preparation of plans and specifications, neither should the contractor be put to the expense of thoroughly checking the engineer's estimates, and all engineering and contractors' organizations should join in an effort to educate specification writers to a proper conception of what is fair and equitable to owners, engineers and contractors.

In Great Britain carefully prepared schedules as to quantities are submitted to the contractor. These quantities are guaranteed, and in case of error, the contractor has a ground of action against the quantity surveyor if his bill of quantities is wrong. This method enables the contractor to estimate much more closely as to the cost of the work than under customs in this country, where all estimates of quantities are *frankly* labeled as guesses, and the engineer dodges all responsibility by stating that the contractor must assume all the hazard as to errors in such estimates. Of course, the contractor under these conditions, must charge for an element of chance which should not enter into the proposition. The engineer should make his estimates carefully and thoroughly and be ready to stand behind them in case of error. I know of but one bridge engineer who guarantees his quantity estimates and as a result bidders can make much closer estimates, knowing as they do, that he will stand responsible for any errors in his quantity statements.

An unfair engineering practice frequently resorted to in the writing of specifications is to require the contractor to prepare the detailed working drawings for the job, including, for reinforced concrete, bending diagrams and special details as to connections of reinforcement, thereby making it necessary for the

contractor to maintain a much more extensive engineering and drafting department than would be otherwise required if the engineer did his full duty, preparing all detail plans and working drawings so that there would be no question in the contractor's mind, when he bid on the work, exactly how the work was to be executed to the most minute detail. In addition to this, some specifications require that the contractor "having checked the plans shall be responsible for the correctness of all drawings, as to dimensions, elevations and mutual corelation of various parts," thereby making the contractor absolutely responsible for the correctness of the engineer's design and drawings, and in case of an error, the expense of correction is unfairly placed on the contractor. The contractor is allowed no extra allowance for preparing these drawings, but must do it at his own expense and deduct it from his estimated profits, when it should be taken from the engineer's fee. Many engineers even require that the contractor furnish several sets of cloth mounted drawings, and as many sets of paper blue print copies as the purchaser and engineer may desire. This might result in an almost unlimited abuse, and while it is a small item on a large job, it would be one of the mice that eats away the substance of the contractor's estimated profit.

Our position in the matter of detailed specifications is that we know of no legitimate reason why the contractor should not have full detailed information as to what will be required in the execution of a given contract *before* the contract is signed, rather than make haphazard guesses on small scale drawings and indefinite specifications frequently lacking in vital information. If detailed drawings have not been completed before the date upon which bids are requested, the date should be postponed to give the engineer an opportunity to prepare complete working drawings. It takes no longer to study the details of a structure before the contract is executed than after, and a careful preparation of detailed drawings and the writing of complete specifications, would frequently result in saving of cost to the owner because of the necessity of the contractor to add a certain per cent to cover the uncertainties of plans and specifications.

Another question in which many engineers err in judgment, is in specifying a short time for completion and requiring the starting of work immediately upon the awarding of contract. A short limit reduces competition because it admits only the con-

tractor who is fully equipped and ready to begin immediate work, and where a short time limit is provided, the engineer should include a certain compensation to cover the cost of night work necessary on the part of the contractor in order to complete the work within the time set. It has been our experience that where the engineer co-operates with the contractor, the quality of work is very much improved, resulting in a great benefit to the owner. Of course, if the contractor knows that the engineer is disposed to treat him fairly and not impose unnecessary hardships upon him, he will in return for this confidence, exert every effort to give the owner the benefit of his experience in producing the highest class of results. If the engineers will write their specifications with the most complete details, setting out definitely in every paragraph what is expected, how it is expected to be done, avoid all reference "to the satisfaction of the engineer," then when the contract is commenced the contractor understands the case, what he is expected to produce for the compensation promised him, and there is no argument, no quibbling and no trouble. An owner gets a high class piece of work, the contractor gets paid for doing it and the engineer reaps the credit for the design. The classification of excavation materials is one that has probably caused as many controversies as any other single item in an engineer's specifications, and this point should be fully covered in all specifications so as to entirely eliminate the necessity for guessing at information which the engineer himself might supply, and it would be far better for the owner if more frequently some preliminary money was spent in test pits and borings to ascertain the character of the soil to be encountered in excavation.

One of the most dangerous conditions in the great majority of specifications is the clause providing that the engineer shall be the final judge as to the interpretation of the specifications. The lawyer would call this ex parte, for the reason that the engineer is in the employ of the owner, and his judgment is bound to be biased toward that side. Of course, I realize that the engineering profession takes the high and lofty position that his judgment will be fair to both contractor and owner, that he is, like Caesar's wife, above reproach, and that the contractor should have faith enough in him to believe that the engineer will give him a square deal; and unfortunately the ranks of the contractors contain many poor boobs who still believe that is true.

Investigation and inquiry among hundreds of contractors has convinced me that this presumed fairness and equity on the part of the engineer is the exception and not the rule.

One manifestly unfair condition in many specifications is that of giving the engineers the right to make minor changes in the plans, without extra compensation to the contractor, unless "in the opinion of the engineer" he is entitled to such extra compensation, the amount of any such extra compensation to be determined solely by the engineer. This condition leaves a very large opening and opportunity for the engineer to abuse his authority over a contractor whom he does not like, or seriously cripple him, when the wrong man, in the opinion of the engineer, has landed the job.

One of the ideals of the American Society of Engineering Contractors is that the specifications should provide in the event of any disagreement between the contractor and engineer, regarding the reading of the plans or the interpretation of the specifications, the quality of the work, the justice of any claim for extras, or any other controversy arising out of the contract or the specifications, that such question shall be submitted to arbitration—the engineer and owner on the one side and the contractor on the other, being bound beyond appeal, to the decision of the arbitrators. In our opinion, this removes the danger of the contractor being injured by the decision of the engineer, or the owner being defrauded by any unfair work of the contractor. It would mean the elimination of controversies between engineer and contractor and place their relations on the broad peace basis of arbitration, that is bound to be a controlling spirit in future times, which we trust are not far distant.

One of the greatest injustices in my mind, which enters into nearly all specifications, is the clause requiring the contractor to "indemnify, keep and save harmless the owner and engineer from all liabilities, judgments or costs and expenses which may in any wise come against the owner or engineer on account of any infringement of any patent on the use of any design, material, machinery, device or apparatus used in the performance of the contract." In other words, the engineer goes along, prepares his design, specifies his materials and method of construction and puts the responsibility on the contractor for ascertaining whether or not there are any patents on the type of design, or material used or on the method of construction. It seems to

me that this is part of the duty of the engineer, and that in making his design he should ascertain beyond the possibility of a doubt whether or not his design infringes any of the many patents which have been granted by the Patent Office at Washington, and in case he cannot make a design without infringing a patent, he should either notify all bidders of the existence of such patent, and the fact that his design infringes, or he should obtain from the owner of the patent the right to use it for a specific price on the work. It is entirely unfair to shoulder this responsibility and liability on the contractor, in addition to the many other troubles which he has to guard against in executing the contract. Of course, it would mean that the engineers would have to inform themselves quite extensively as to existing patents, but we as contractors believe *that* is part of the duty included in the engineering service for which he receives pay.

Another inequity is that of giving the engineer the right to direct the sequence of the work and issue orders as to the manner and time in which the various parts of the work shall be done, and the force required to complete it within the time specified. I believe I can state, without fear of contradiction, that no two contractors would handle the same job in the same manner and sequence. It is customary in making up estimates, to carefully plan the manner and sequence of the construction, and if the contractor is not permitted to follow his own methods, it frequently results in turning a contract, that would otherwise be profitable, into one that results in a loss to the contractor. The contractor is the man who pays the bills, who furnishes the surety bond guaranteeing the construction according to plans and specifications, and in a given time, and in my opinion, he should not be hindered or hampered by the opinions or ideas of the engineer, who in most instances has not had a hundredth part of the experience, in actual construction of the type of work covered by the contract, that the contractor has enjoyed or "suffered."

The experience of many contractors has demonstrated that many of the engineering profession are guessers on cost construction with no actual experience to guide them. Of course, we as contractors do not charge the engineering profession with doing this guessing on cost with any malicious intent to injure a contractor, but the result is the same. If an engineer, having

a lack of actual knowledge as to the cost of the various elements making up the construction of a given piece of work, relies on a rough guess, it is bound to bring grief to the contractor, either in the way of blaming him for charging exorbitant prices for the work, or if, as is frequently the case, the contractor has had no personal experience in the cost of this element and uses as a basis for bidding, the engineer's guess, he is bound to get stung. As an illustration of this disposition of engineers to guess, our Company made preliminary estimates on the construction of a bridge last year for which an appropriation of $50,000 had been made. The engineer who prepared the plans advised the commissioner that the bridge could be built with a contractor's profit of 15 per cent for $45,000. In making up our estimate we reached the result that the bridge would cost, without profit, $49,000. Being very friendly with the engineer, we asked him how he arrived at his estimate of cost, and sat down with him to make up what he considered a fair estimate. Each element of cost we took up with him and accepted his figures as to the cost of the principal component parts. When we had finished with his elements we called his attention to the fact that he had not included in his estimate of cost anything whatever for hardware, nails and wire, for conduits and wiring, for removal of centering and forms, for employers and public liability insurance, for surface finish, fuel and oil, traveling expenses or for moving plant. Of course, it was no trouble to convince him that these expenses were bound to be incurred in constructing the work, and when we had added to *his* figures as developed by this conference, *his* ideas of the other elements, his cost estimate ran $3,000 higher than our own, and $2,000 higher than the amount appropriated for the job, with no allowance whatever for profit. When the total was shown him, his reply was: "Well, I know the bridge can be built for $45,000, including a liberal profit for the contractor." In other words showing the actual figures had no effect whatever on this engineer's *superior* knowledge; he simply reiterated his original charge and let it go at that, and this engineer enjoys a good reputation as a competent bridge designer in the locality where he practices. Incidentally, I might add, the contract was let for $47,000 and the contractor dropped $6,000 of his own good money in executing the job.

Many engineers who use some of the old text books on

estimating and cost data, do not seem to realize that the world moves rapidly and that improvements in construction have gone along hand-in-hand with improvements in other lines of business. A notable example of this is the great change in the writing of specifications as to dry and wet concrete. It has not been long since concrete specifications would provide how the concrete should be *tamped* in place in layers, and all that sort of thing, which is at the present time almost a forgotten condition except in pavement foundation. In like manner, there have been many improvements and changes in the methods of building coffer-dams, making excavations, placing reinforcing steel and building forms. Notable among the improvements in concrete placing is the use of the pneumatic process whereby the aggregate is mixed and shot into place without being touched by hand, a process that is bound to revolutionize the mixing and placing of concrete in certain types of construction. I speak advisedly along this line, for the reason that our Company placed thousands of yards of concrete in bridge construction during the last year entirely by compressed air, and in some types of construction, with approved aggregate, the cost of placing concrete by this method shows a phenomenally low figure.

Many contractors hesitate, and some even refuse, to furnish engineers any details as to actual cost data, which in my opinion, is more injurious to contractors than to the engineers. If contractors would supply the engineering profession with actual experience data, I have no doubt the engineers would be glad to use it in making future estimates, but it is doubtful if the contractors as a class can be convinced that this method would correct frequent carelessness and loose methods in making up estimates by engineers.

Another practice followed by some engineers is the trimming and pruning of monthly estimates for payment. As a general proposition the engineer or inspector directly in charge of the job, who is frequently a young man, will make a *decided* practice of *underestimating* work actually done, refuse to include in his estimate many items which, in equity, a contractor should be allowed, and then, after taking off the percentage held back as provided by the contract, a contractor gets in reality 50 or 60 per cent of his work actually done where he should get 80 or 90 per cent. Of course, this has no bearing

on the engineer's ability, but it frequently embarrasses the contractor in financing big jobs. We all know the average contractor will take on work in excess of what he really should undertake with a fair and reasonable consideration of his financial ability, which frequently makes it necessary for him to watch every corner, and make many twists and turns in a financial way to meet his payrolls and material bills. This is chargeable in most instances to ambition and an eagerness to make money, but when this condition is evident, and on top of this, the engineer trims his estimate approximately 20 or 30 per cent below what the contractor is entitled to receive and has reasonably expected, it very often gets him between the millstones of the banks, which proverbially grind slowly but they grind exceeding fine. An important point in the preparation of estimates for pay, which I believe contractors will bear me out in, is that engineers should make an allowance for material on the ground ready to be worked up, a sum covering forms and preliminary work, and in some instances a sum approximating the cost of new equipment that is to be bought to handle the especial job. Of course, I realize that the engineer will say that many contractors will be unreasonable in these claims, but if the engineers would show a disposition to help the contractor along these lines, I believe that 90 per cent of the contractors would be disposed to strain points in favor of the engineer and owner, and give them a higher type of construction. It would be nothing more than an appreciation of a favor extended, and along this line, we are all human and willing to show our appreciation of any such help.

The business relations between the contractor and the engineer are little understood by the public at large. We frequently hear a contractor on public work condemned for failures in bridges, roads or pavements, when he was entirely innocent, having built the work in strict accordance with specifications furnished, yet the general public makes him the goat, and the engineer, who has prepared faulty specifications, goes "Scot free." Of course, the engineer may take the high position that if the contractor does not like his specifications, he need not bid on the work, but this is not only unfair to the contractor but also to the owner, because it reduces competition by eliminating intelligent and responsible contractors. Some contractors go so far as to refuse to bid on work where the specifications are not

fair and completely detailed, but where a contractor has a large organization with a certain amount of overhead expense, he is, of course, anxious to make as good a showing on the capital invested as he can, hence by passing up unfair specifications, many pieces of work which he could do at a profit under fair specifications, are lost. We, as contractors, realize that one of the most difficult problems confronting an engineer is the preparation of his specifications, in making them rigid enough to control the bad contractor and at the same time work no hardship on the contractor who is honest and sincere in his work.

A prominent engineer, in a paper recently read, refers to the personality of the engineer as probably the most important factor in the relations between engineer and contractor, stating that some engineers have a notoriously bad name and do not seem to appreciate the responsibility of the honorable position they occupy. If the contract is used merely as a legal document to hold over the contractor's head as a club and unnecessary harassing and vexatious conditions insisted on, trouble will surely follow. The wise engineer knows that many contract conditions can be ignored without any harm being done, and that many facilities can be given the contractor to help expedite the work. We believe that the contractors as a body will not take unfair advantage of these concessions, but in their turn, will go out of their way even at extra expense, to meet some special request of the engineer, playing the game of give and take in a reasonable way without expecting extra pay for every trifling piece of work, thus bringing about a great improvement in the relations between engineer and contractor and eliminating many of the disputes which at present are too frequent.

The National Association of Builders Exchanges, of which Mr. H. L. Lewman of Louisville, Ky., is the president, in conjunction with the American Institute of Architects, has been working for a number of years to secure standard specifications and contracts for the use of builders. Their effort has been

> "To accurately define and standardize, wherever practicable, plans and specifications in order to eliminate unnecessary hazards and uncertainties in construction contracts;
>
> To reduce the cost of improvement to the owner;
>
> To give the contractors and surety companies a proper understanding of the obligations they assume.

To establish contracting and suretyship on a more stable and definite basis;

To provide for the settlement of differences by some equitably constituted authority;

To establish building contracts on such a basis that banks and commercial institutions may intelligently determine the amount of credit to be extended to owners and contractors, and to eliminate the present uncertain conditions of credit based on such contracts."

How well they have accomplished this work is evidenced by "The Standard Documents of the American Institute of Architects in collaboration with the National Association of Builders Exchanges." These documents define the duty, scope and power of the architect, the duty of the contractors, the scope and limit of arbitration, the rights of sub-contractors and a carefully prepared, detailed article entitled "Advice to Contractors" by Mr. William B. King, general counsel to the National Association of Builders Exchanges. The specifications and contract forms have been so carefully prepared and revised that it is difficult to find any point wherein there can be criticism. Their theory is to insist upon the use of the principle of arbitration on every possible question that can be settled without resort to the courts. But the greatest lesson to be derived from this joint work of these two great national organizations is the benefits and justice that are sure to accrue as a result of the joint organization, co-operation and close affiliation. The result has been to increase the membership of the National Association of Builders Exchanges more than double during the year of 1913, which number was doubled in 1914 and almost doubled so far in 1915, making this organization now one of the largest and most powerful commercial organizations in the United States, representing as it does, the broad field of building construction, which judged on a financial basis, is probably the largest branch of commerce in this country. If it were possible to bring about such close relations and affiliations between the various national engineering societies, and all of the national contractors organizations, it would be a result which would be beneficial to all engineers and contractors and almost entirely eliminate losses caused by misunderstandings of con-

tracts and specifications. Such a uniform action could bring about an adoption of standard specifications and contract based upon equity, intelligence and fair dealing, ever guarded by the idea of arbitration. It is my fondest hope as the executive head of the American Society of Engineering Contractors, that the day is not far distant when all of the National, State and local organizations of Engineers and Contractors may be brought into such close relationship and co-operation that equitable specifications and contracts will be the rule instead of the exception, resulting in standard forms that will not only represent fully the engineer's ideas but will be fair to the contractor and economical to the owner. I cannot imagine a better declaration of principles and creed than that of the International Rotary Clubs, and if we can get together under some such banner, we can exemplify to the letter the motto of that magnificent organization—"He profits most who serves best."

DISCUSSION.

Mr. C. E. Smith. Mr. Hackedorn's paper presents to engineers and architects, in a very illuminating and enlightening way, a matter that has been discussed from time immemorial, and if the matter had been presented earlier and more often along the lines discussed by Mr. Hackedorn, and if engineers and architects had profited by the suggestions and suggestive criticisms contained in his paper to the extent that they deserve, there would be less discussion of the matter to-day.

Specifications too often cover up, by general sweeping requirements, the lack of information or inexperience of the writer, and as a result the contractor finds it necessary to provide for the element of "ignorance," by adding a substantial percentage to his bid to provide for the unseen.

There is no reason whatever why specifications should contain such general clauses, nor why there should be the least particle of indefiniteness in the specifications. If there is work to be done, that is not thoroughly understood by the engineer, it would be far better to omit it entirely from the specifications and give the actual cost of performing the work, plus a reasonable percentage, when the work becomes necessary, as that would be far preferable to having the contractor guess at what might arise, and in most cases add to the bid a larger amount than would otherwise be paid. There seems to be a general impression

among engineers and owners, that payment for extra work represents a loss to the owner to which the contractor is not entitled but which he forces through his interpretation of the specifications.

If the specifications be made so clear and positive, that there is no doubt whatever in the minds of the engineer, or architect or contractor, as to every detail of the work to be performed, the contractor will prepare a close bid on a thorough understanding of the requirements. If contingencies later arise that require additional work to be performed, or if work that has been overlooked and not included in the specifications comes to hand, the payment of actual cost, plus a reasonable percentage for such work, will usually entail the payment of no more money than would have been included in the bid of the contractor, had extra work been required, and provided for in the original specifications on which he bid.

It is, of course, preferable to avoid such extras by preparing plans and specifications complete in every detail, but conditions frequently prevent this being done. These conditions are, lack of time, neglect of owner, engineer or architect, to make expenditures sufficiently large to cover the cost of complete preparation of such plans and specifications, or the ignorance and inexperience of architect and engineer.

Conditions embarrassing to the engineer or architect sometimes arise through underestimating and later omitting from the plans and specifications essential features of work; thus work is frequently awarded under a bid which appears sufficiently large to complete the work within the estimate, but the extra cost of providing for the omission soon makes it evident that the actual cost of the work, if extras be awarded, will far exceed the estimate. Under such conditions the engineer or architect is placed between two horns of a dilemma. He must either explain to his client that his estimate was too low and that the bid did not cover the entire work on account of omission from the plans and specifications, or he must endeavor to compel the contractor to carry out the extra work under his original bid. Unfortunately, the latter course is frequently chosen, and a practical admission that engineers and architects deliberately intend to take such a course is contained in the wording of many obscure requirements and specifications. Only too often it is possible for an engineer to turn down claims of a contractor for extra work

honestly performed that was not contemplated by the contractor when he prepared his bid; in such cases obscure clauses in the specifications frequently make it impossible for him to recover his just dues.

Under the above conditions, it is not to be supposed contractors will always accept the letter of the specifications in bidding on such obscure clauses, and in figuring, frequently discounts the binding effect of the clauses, assuming that extras may be easily collected.

A standard clause in the specifications of a large railroad company, with which I was connected, required that the contractor take the work on his own knowledge of local conditions, and not based on the information furnished him by the railroad. Frequently the conditions encountered were very materially different from those contemplated, but the time between the request for bids and the opening of the bids, would not have been sufficient for the contractor to have informed himself. Manifestly the company should have spent sufficient for engineering to have made the necessary investigations, so that all the bidders would understand the situation alike. Regardless of that provision, however, contractors repeatedly presented extras when different conditions were encountered, and no doubt could have enforced their claims for extra payment on that account, but on account of the wording of the specifications, which formed part of the contract, the engineers found it difficult to make the proper adjustments.

Mr. Hackedorn suggests a proper remedy, or rather a preventive, in recommending that more complete plans and specifications be provided, in order that bidders may be relieved of any doubts and uncertainties, and if this advice be followed, I am sure there would be less confusion and disagreement in these matters.

Mr. F. C. Woermann. There is a great quantity of food for thought in Mr. Hackedorn's paper and I trust it will induce some of our engineers, architects and contractors to give these matters serious attention.

To obtain the best results, it is essential to have a competent engineer, architect or superintendent representing the owner, and it is no less essential to have a competent contractor doing the work. With this combination the work will be executed quickly and economically, and the great majority of the owners will be

satisfied with the result. There are, as we all know, some owners who cannot be satisfied, but they are only a small minority. Competent men will work in accord, each doing his duty and not interfering with the duties of the others. If, however, one or more of the parties are incompetent there is apt to be unnecessary trouble and expense.

A great deal of worry, expense, and poor work would be avoided if the contractor received a reasonable price for his work, and the majority of owners would be willing to pay this price if it was presented in the proper light by the engineers and architects in charge of the design. It seems to be customary for engineers and architects to greatly underestimate the cost of their designs and as a result a large percentage of the work is not built as designed on account of the proposals being higher than the original estimate. If the work does go forward, it is generally on the basis of a redesign and after it has been refigured by the contractors. The redesign and refiguring naturally add an additional expense to both the designer and the contractor, and often in the case of the contractor at least, it costs as much to make a new estimate as it did to prepare the first one. This expense could often be avoided if more study was given to the first design, and if the owner was given an intelligent idea of the cost of the work.

I wish to call your attention to one other matter which is not fair to the contractor, and which has caused a great deal of ill feeling and dissatisfaction in the past. I refer to the manner of opening bids in private. There is no good excuse for this practise, and if it is intended to let the work to the lowest responsible bidder, there is no reason why all contractors interested should not be invited to the opening. If one or more of the contractors are not responsible, they should not be allowed to bid. The time to eliminate them is before they have spent their time and money making an estimate.

It is not necessary to award the contract to the lowest bidder, but if the owner thinks one contractor will give him better service than another he should be willing to pay the difference in the amounts of the proposals, in order to get the result desired.

It should always be remembered that a favored contractor who knows he will be given an opportunity to meet his com-

petitor's figure will seldom give his lowest estimate the first time. If he did there would be a possibility that he would be the low bidder and be given the contract at his figure and the advantage of meeting his competitor's price would be lost. I believe that in most cases where there is a favorite contractor, the owner pays more for his job than he would if only responsible contractors were invited to bid and the contract was awarded to the lowest bidder at a public opening.

Mr. D. H. Kremer. Mr. Hackedorn covered the subject of "Equitable Specifications and Contracts" forcefully and frankly. He refers to the harmonious conditions existing among the Associated Engineering Societies of St. Louis. From his observation I should say that he is a man of quick conception and keen judgment.

The contracts offered by the Engineers in the City of St. Louis are, as a rule, fairer than those offered elsewhere, and especially in the smaller cities. I can see no reason, however, why the standard forms, adopted by associations, should not be in general use. Small municipalities are usually burdened by an attorney who, to earn his pay, must make up a form of contract according to his own ideas. The engineer is totally disregarded, except as to description of the work to be done, and as a result, a one-sided contract is made. This also refers to some of our transportation companies. Some of our most liberal and best railroad engineers are compelled to offer contracts, made by the legal departments, which they know to be manifestly unfair.

Many contracts are offered which provide no arbitration clause except that "the engineer is made and appointed the sole arbiter of any differences, etc." All of us know this to be unfair, but practically all contractors are so anxious for work that they will sign most anything to get a job and trust in Providence in its execution. There is reason to believe that where two men disagree in the execution of a piece of work, or in interpretation of contract and specifications, there is an honest difference of opinion. Then why not settle *all* differences, not possible to settle by argument, by arbitration? It has been my experience that the most liberal minded are those who get the best results, both in prices and in the execution of the work. The personality of the engineer or architect is nearly always a great factor in determining the price which most contractors make, and in the acceptance of the terms of the contract offered.

Mr. Hackedorn spoke of the Quantity Survey System as used in Great Britain. This has been under discussion for some time by the Engineers' Club, the local chapter of the American Institute of Architects and The Building Industries Association. A committee consisting of three members from each association has been holding regular meetings to consider this and other subjects of mutual interest, and has recommended the adoption of the system. For the fee of making this survey several suggestions were made. Treat it as an item of cost, specifying the allowances to be made by the contractor, such as is done for finish hardware; increase the amount of engineer's fee, or have the owner pay a fixed sum for the service of the engineer.

I do not agree with Mr. Hackedorn in his criticism of the specifications requiring the contractor to make his own shop details, although it may be just in his particular line of work. In buildings, the structural steel sub-contractor prefers to make his own details. He has certain shop standards, standard size and especially printed drawings and an engineering force. Some shops charge more where they are provided with details, than if they made them. The same, I believe, applies to many of the reinforcing steel companies. Their fee, at any rate, is so low, and their opportunities for saving, so great, that it is probably cheaper to have them make their details.

There was some mention made of the unbalanced estimate of cost. Under existing conditions I consider the unbalanced cost estimate the only fair estimate a contractor can make, but I believe in it being done honestly. If the contractor was allowed to draw monthly on account of all his actual physical costs, not covered by items in specifications, there would be no reason to unbalance the estimate. The permits, bond, and insurance must be bought before starting work; plant must be hauled and a lot of miscellaneous work and materials furnished before construction starts. All this, under existing conditions, is in the estimate for excavation and foundation. Why not recognize these physical costs, not overheads, and include in estimate?

Mr. Hackedorn has fully covered the ground in other matters. There seems to me no reason why the engineer and contractor do not get together and agree on some definite forms, covering general conditions of specifications and contracts.

These should clearly define our status and provide for arbitration of all disputes.

The Standard Documents, etc., referred to by Mr. Hackedorn, are the result of three years of negotiations between the American Institute of Architects and the National Association of Builders Exchanges. They were assisted by Mr. Wm. B. King, who, I am informed, is the attorney for the Court of Claims at Washington, D. C. He, probably, has had as much or more experience in contracts than any lawyer in the United States and was well qualified to act as adviser.

Inasmuch as these "Standard Documents" have been accepted by the Architect and Contractor, why not by the Engineer? Are they not worth considering?

Mr. A. P. Greensfelder. The paper Mr. Hackedorn has read this evening should be an inspiration to construction engineers and engineering contractors, and every member of the St. Louis Branch of the American Society of Engineering Contractors can feel just pride in belonging to a National organization which chooses such an able man as its President. We are sincerely complimented through the courtesy shown our local Section by the Speaker making a special trip from Indianapolis especially to favor us this evening and personally, I am pleased to meet an engineering contractor of such wide experience and with such a breadth of view and vision. He fully exemplifies the obligations and duties of leadership through his willingness to make personal sacrifices for his profession. Such an example cannot fail to make a deep impression upon his auditors tonight, and our formal vote of thanks will be but a small indication of our appreciation of both his presence and his paper.

Mr. Hackedorn in his paper touches on many timely topics on the equity in contracts and specifications, and thus calls forth discussion which not only proves interest in the subject, but which is of equal importance and tends to emphasize the vitality of his propositions.

Quantity surveying is bound to become popular as soon as its merits are thoroughly understood, and St. Louis comes to the front by recognition, through City Ordinance, of "Quantity Surveyors" under bond to perform such work.

The application of patents on any job might be readily ascertained by the engineer, through patent attorneys, or by inspection

bureaus annexing this field of operation to their present services.

The design of concrete work by the engineer might well include typical designs of forms to support same. Alternate designs of supports might be permitted by the engineer upon request, if checked for strength and tightness. Such methods would certainly be conducive to better results and fairer engineering than to simply specify 2 in. sheating without mentioning the necessary supports.

Since universal knowledge is exceedingly rare, we know that specifications are copied and copied again. It is queer how the original meaning of certain clauses, perhaps necessary in the ancient original, become impractical and distorted in the latest issue.

There can be no disagreement that the time to limit the number of bidders on private work, in order to insure responsibility and fitness, is when plans are sent out and not when bids are called in. Proof of ability to furnish surety, plant and capital, might also well be required of bidders on public work in advance of lettings rather than confusion, delays and expenses of relettings.

Reduction of uncertainties to a minimum by the engineer are surely due the contractor who at all times has beyond his control the "handful" of weather, underground conditions, labor strikes, material deliveries and machinery flaws.

Mutual regard for personal judgment and weight of experience might well be cultivated by both the engineer and the contractor on every job, and should result in less bickering and more amicable relations with the better working results that follow.

Extra compensation seems to be the confirmed bacillus against which all engineers inoculate themselves at college graduation. How much more interesting and fair it would be if the engineer devoted his spare moments in noting "values received" instead. Both his clients, the owner and his employe,—the contractor,—would thus be better served.

There are usually ninety-nine right ways and one wrong way of doing a particular job, and the numerous contractors while reserving the privilege of choosing the particular variety of method, are just as anxious as the engineer in charge to avoid the one pit-fall.

It seems unusually common, but true nevertheless, that engineers on construction work are not the least concerned about unit costs. One might think such information would be valuable data

to say the least. and besides interest in such matters might suggest mutual sympathy between the struggling contractor and his supervisor.

Might not the temptation to unbalance bids be largely removed, if engineers would agree to allow, in their monthly estimates for plant installed, materials furnished or falsework erected? Unbalanced bidding is often also suggested by unbalanced quantities.

Lastly, let us not forget that the human element plays a most important part in any task to convert nature to the uses of man. It is on occasions such as this, therefore, when engineers and contractors meet fraternally, that we can get together, see ourselves as others see us, and take away a more generous appreciation of each others problems and viewpoints. In providing such opportunities the American Society of Engineering Contractors can well take the lead.

THE BROADER DUTIES OF THE ENGINEER.

By J. C. Ralston.*

[Read before the Oregon Society of Engineers, November 18, 1915.]

Engineering history, so far as human records go, has its beginning in the classical legends of Ovid and Virgil. It is related that one of the gods of Greek mythology, Daedalus, was a great artificer. Aside from discovering the saw, the gimlet and the scriber's compass, he was the builder of the famed labyrinth of King Minos, in which at a later period he was imprisoned by the King. Escaping, he deigned to conquer the regions of the air. Accordingly, he fashioned wings of feathers, sealing them together with wax. Putting one pair on his son, Icarus, and one upon himself, they flew off into the empyreal regions. And thus was recorded the first successful attempt at aviation engineering.

Before starting upon their perilous journey, he cautioned his son, in fear and trembling: "Icarus, my son, I charge you to keep at a moderate height, for if you fly too low the damp will clog your wings, and if too high the heat will melt them." But the boy, exulting in his flight, left the guidance of his father, and flying up and up towards the sun, soon found the wax melting and the feathers loosening, and so he fell into the Icarian Sea and was drowned.

In addition to giving the world its first lesson in aviation, and in devising many useful articles for the mechanic arts, he gave all engineers a superb maxim. It might well be made a book-plate or a motto. "Keep at a moderate height, for if one flies too low the damp will clog one's wings, and if too high the heat will melt them."

It suggests that middle ground which the profession, if it is to rise to the broader duties of the call of the times, must adopt as its guiding motto.

When we look about us, and see the utopian nostrums affecting engineering projects which are advocated in the legislative halls of the nation and the various states, we may easily discern the need for advocating that moderate height which leads to permanent accomplishment. Or, on the other hand, if we contemplate the vicious forces which seem to be a world-wide ob-

*Member of the American Society of Mechanical Engineers, Spokane, Wash.

session of the hour, we will find inspiration in the charge of Daedalus.

Engineers ought to recognize—perhaps many do—that engineering and industry are not in themselves ends, but rather are they means to the greater end of promoting the happiness, welfare and prosperity of the world. A great bridge is not only a vehicle of transportation, facilitating the intercourse of humanity, but it should also be made to embellish the city for which it is built, and to be expressive of that genius of the profession which seeks to translate itself into terms of combined utility and adornment. This was the dominant thought of the builders of such artistic monuments as some of the Tiber bridges of Rome, of the Ponta del a Trinite, in Florence; or the Rialto over the Grand Canal in Venice; the Alexander and others over the Seine, the new London bridge and some of the old English stone bridges, as well as some of the more modern ones in America.

Similarly, a great invention, say, in telephone engineering, or the perfecting of a fertilizer manufactory, are not alone triumphs in engineering, but they are permanent contributions to the prosperity and welfare of the nation. Neither one is to be measured alone by the financial results which they secure for their promoters but taken together with all our works are the stones in the Parthenon of our civilization.

And so we may perceive that we possess, if we will but visualize them, broad and inspiring foundations upon which to outline our fundamental perspective. Nor need we fix the vanishing point against an immediate or modern horizon; but rather should we place it behind the background of all engineering history. In vision we may thus become the cosmopolitan mind, universal in attributes, high in attainments, and great in accomplishments.

We must, then, no longer retain the prevailing inherited narrow notion of the profession. We are both scientific and practical men; for the former presupposes research which takes cognizance of the past, the present and the future, while the latter is guided by the hard and fast rules of utility and feasibility. More than this, we are the scouts and pioneers of material advancement, the builders of the outposts as well as of the permanent temples of civilization.

I would proclaim this from the house tops. I would let the world know that we are more than advanced artizans—more than designers and superintendents. Let it be known that we have

a speaking voice and a trained mind capable of making themselves felt in the council of the big things of the world.

Many there are who decry the entry of engineers into politics, and they are right if they mean that type of politics which is followed for personal aggrandizement or mere expediency. They are wrong if they mean that engineers should not take a part in politics where the public is in need of information, advice and guidance on questions in which matters either cognate or remotely connected with engineering are concerned, or upon general economic or industrial problems.

The ignorance or indifference of the public and public officers towards the functions and offices of the profession is, in a large measure, the result of an unconscious conspiracy of silence on the part of the engineers, themselves. If we were more active in public affairs, and kept our political and economic thoughts directed along that "moderate height" of which I have spoken, ours would not be the hermit profession. By this very silence the engineer has deprived himself of opportunity and has denied the public the privilege of a better knowledge of his trained and, let me say, more accomplished mind. For I conceive it to be true that the mind of the engineer is as capable of leaving the narrower confines of technical duties as are the minds of those other professions which have distinguished themselves in the political and social activities of an advancing world, without militating against their professional standing. In this we may sense some of the broader duties of the engineer.

As a corollary, it follows that the engineer should be a man of clear, convincing and pleasing address—a master of rhetoric and synonyms, able to dress his thoughts in the glass of fashion and the mould of form, and to translate the broader aspects of his profession into terms and vision which the public will understand. "Speech is the instrument by which the fool is distinguished from the philosopher."

There is little doubt that the country will shortly undertake new, broad and far-reaching policies in economic, social and political activities, changing the whole complexion of our traditions. Engineering in certain lines will be given a distinct impetus; but it threatens to be an impetus under which individualism will be forced to give way to collective, corporate and nationally controlled engineering. The salaried engineer alone will be ubiquitous. The private practitioner and the consulting

engineer, as we know them today, will be strange and lonesome figures. Paternalism, already gripping the throat of a thoughtless nation, will then more actively than ever fasten its grip upon the republic, unless leaders arise who will direct the nation away from its false gods.

Efficient preparedness cannot be attained without the directing force of a strong central government, yet such a government, in the human nature of the present unfortunate socialistic tendency of a large part of the unthinking public, will incline perhaps unconsciously, though with a suspicious deliberation, to take into its hands, in one form or another, the control of many activities which traditionally are wholly outside the function of constitutional government. And here again is where the engineer must make his sobering influence felt in helping to shape public thought and general legislation into channels of practical utility, and away from the paternalistic tendency towards bureaucracy.

It is not idle to hope that the engineer may be a directing force of great consequence in this forthcoming national movement, not merely because his profession is a necessary arm of the national defense; but because, knowing his own worth, he can more accurately define serviceable citizenship. He is naturally an organizer of men. He can also be an organizer of intellect. He should be the councillor's mind and the advocate's voice. Give him the tendency of the times, and he should be able to visualize the future.

The late James G. Blaine once said that the man in office is always a willing listener to any suggestion for the expansion of his jurisdiction. The engineers of the country have recently seen the strange spectacle of bureau chiefs and employees actually invading engineering and industrial fields, by laying down rules and prescribing standards of construction and even moral conduct which only the theory of paternalism with its implication of private incompetency and fatuous dependence alone warrants.

May I reverently ask, shall we make obeisance to the human intellect behind such a conception of the private citizen; or may I not, with reasonable fidelity, like Ambrose Bierce, define brains as a substance which under our beneficent form of democratic government is so highly honored that it is rewarded by exemption from the cares of office? Verily, there are some governmental incursions into the field of private activities as grotesque as a medieval gargoyle which need not be chiseled off the national

waterspout, but need only be laughed off. Perhaps the time may come when we will have to add the merry and explosive, inarticulate compound of laughter to our laboratory, and thus with psychology enlarge our field of broader duties.

Other activities there are which have been strangled to death, so that today project engineering is merely a memory. Nearly all of them are vital to national development. Lack of vision on the part of our legislators and administrative officers, and a misconception of the public will, have perverted nearly every national tradition. Through it all the voice of the engineer has been strangely silent.

The development of many of our industries which depend upon government sanction for their inception have been killed, I believe, not so much through deliberation, as through a misguided, though a conscientious effort on the part of the so-called conservationists to preserve something which they seem to regard as intangible and speculative for a posterity which is assumed will be incompetent and dependent. In these matters we discern how the aphorism of the late Mr. Blaine applies; for bureau after bureau, like dragons' teeth, have sprung up to strangle and kill.

We all remember reading how Diocletian established the Partnership Emperors, about 300 A. D., and how he thereafter remodeled the state into the greatest system of bureaus the world has ever seen. But, alas, the pages of history succeeding the domination of the Bureaucratic Emperors are mercilessly filled with the most dismal annals of human decay; for the outcome of Bureaucracy was the Dark Ages.

Our civilization has spent a thousand years struggling through the Dark and Middle Ages, and has taken but a single flower from that long, said period—the flower of chivalry. Nearly five hundred more have given us great nations and great governments; but the lasting flower is yet unnamed.

Is history to repeat itself, and revive the Apostolic Succession in Bureaucracy?

I say that vision is the whole philosophy of engineering. It embraces every dimension of that philosophy, and is based upon ideals. Ideals in turn are the outcome of practice. Thus in national ideals, with their three basal divisions, the engineer should be the great outstanding, dominant figure.

In social ideals, which fall to the state, because the state's

concern is with public welfare, the engineer is the inner and the outer barrier.

Artistic ideals which in public and private works, in national, state and civic undertakings, give taste and direction to the public mind, the engineer must be considered as of the academy.

Industrial ideals fall almost exclusively to the engineer. They embrace his entire technology, and engage his ripest knowledge in political economy, economics, civics and government.

If these ideals thus so intimately concern the engineer, who, then, shall shape the industrial policy of the nation—a policy as yet unformed, and therefore unhampered by traditions? Shall it be the politician or the engineer? The former is already an assertive, active agent; the latter is, I fear, emasculated by his own inertia and by his failure to grasp the essential elements of vision and the broader duties of his profession.

When I spoke of industrial ideals, I had in mind among other things the probable realignment of our industrial system when the fierceness of European competition makes itself felt. If there is any engineer who still harbors notions of unrestricted international trade, he should bury them as deeply as a certain national party is now apparently preparing to perform that mortuary service. There are also certain other fundamentals underlying national prosperity with which the engineer must be familiar before his voice and influence may be effective in behalf of his country, his profession and himself. He must know, for instance, that the primals of industrial and commercial organization, fostered as they have been in Germany and the United Kingdom, must be similarly fostered by our own government, and not strangled by nostrums and political impediments.

It is the outward and visible suppression of the nation, not the invisible government, under various guises, actuated by sincere but false expedients, which are tending to denationalize our political institutions. Old fashioned American thrift and patriotism, smothered as they have been in the immediate past, must be promoted. The anchors of society and religion now being ruthlessly uprooted, must be imbedded again more firmly than ever before. The garroting of organization, co-operation and initiative in American industry must be superseded by the practice of national encouragement. Perverted conservation, with all its fabian fads, must be gently but firmly driven to the shambles, and rational conservation substituted.

These, I say, are some of the broad questions which the engineer must at least partly understand before his voice may be heard and before the full membership will know that there are indeed many broad and comprehensive duties inherent in the profession. Need I add that a grasp of this broader view is closely connected with personal success?

And there are some phases of the great overshadowing labor question equally important, because they are cognate to engineering and are persistently present in political and industrial controversy and legislation. Of such the engineer must be a student and an authority. The recent spectacle in England of unionism being directed towards the hastening of national destruction points in a dramatic manner to the extreme limits which this form of selfish organization will go under maladministration.

Striking down the very hand which feeds it is a form of destructive ingratitude which in time will uproot the anchors of any society, totally destroy the national ideals of any country, and finally annihilate the country itself.

A broader concept of engineering will take cognizance of the perversion and maladministration of labor organizations not with the ruthless hand of the overlord, but by kindly, thoughtful sympathetic and cooperative endeavors. Without taking measures to abate some of the apocryphal, if not menacing, conditions of misapplied unionism is like nothing so much as the obtuseness of a reptile crawling on its stomach and hiding its head in the mud.

The world seems lately to have been enamored of military engineering, to its frightful undoing, in this stupendous war of the Cyclops—shall I say, this war of the engineers? Through our works of beneficent utility, the world must be led away from the siren's false love, and become enamored of civil engineering. For I do not believe that the world's intellectual progress has recently become moribund, nor that civilization has suddenly been halted. Surely we are conscious that the flower of knighthood still blooms in the full vigor and fragrance of the morning rose, and that the moral philosophy of our Anglo-Saxon race is still a superlative philosophy.

But the whole world in the present momentous, perhaps monstrous, crisis is suffering a rude and staggering shock—a volcanic awakening. Into a seething, dynamic volcanism has been thrown the democracy of Athens, to be metamorphosed,

possibly, into the hard, cold ideals of Sparta—from "the glory that was Greece, to the grandeur that was Rome."

Whether the historian is to cease writing the annals of the *people* and direct his pen to the history of *dynasties,* profoundly concerns all alike; but in any event, the hour draws near when every citizen of this country may have to recast his concept of citizenship duty. Every human activity, whether domestic, commercial or political, manual or professional is engulfed; and no profession is so deeply nor inextricably involved as that of engineering.

The broader aspects of the profession must now, more than ever before, be founded on a broad, definite and altruistic base, not upon a technologic thesis. Our vision must be no longer confined to the traditions nor the limitations of the classroom, but, like a glorious sun-rise, must sweep the whole national horizon.

I would first secure an affiliation of the various branches of the profession, divested of purely technical color, and resolved into a clearing house for those broader activities of political, commercial and social education which relate to engineering and the matters which may effect engineering as well as the relationship of engineering to the public welfare. And conversely, the education of the public in its attitude towards the profession.

Thereupon, I would expand the bond between the engineering school and engineering profession. Service and sympathy from the outside will enlarge the technological curriculum into that grasp and vision out of which broad-minded men are made. The impress of the field should be put into the life of the student, so that he may sense the future and revere the past. The profession is not measured wholly so much by what it is doing, as by what it has done. Its romance are its achievements. Its promise is its history.

On the other hand, the mantle of pedagogy must be unfolded from its tight and narrow lacing, so that its ampler folds may comfortably embrace the council and help of the practicing engineer. In the last analysis, the schools only reflect the outside practice which the engineer typifies. Cooperation between the college and the profession should be the very joy of living and the essence of human service. Like the quality of mercy, it is twice blest; it blesseth him that gives and him that takes.

I say, that to help in the creation of a closer bond between

the field and the college is one of the broader duties of the engineer.

During 1913 ex-President Taft gave a series of six lectures to the law students of Yale on the broader duties of the American Lawyer. He began with a review of the earliest republics of Greece, and followed on down categorically through the ages, reviewing the Dutch Republic, the Hanseatic and other leagues, and finally to the American Republic and its constitution. He reviewed the defects in each scheme of national government, and the results that followed from those defects and from the loosely knit scheme of federation or league. As to the American constitution he depicted the malign influences now insidiously at work, and the well defined, though perhaps unconscious, breaking away from the fundamentals of the safer closely knit scheme of our type of federation. He showed how the frenzied legislation of some of the states, and of the Federal Congress, for that matter, has led the people so far afield that today many are seriously advocating such wild and fanciful nostrums as the recall of judicial decisions, thus attempting to substitute the voters' sentimental philosophy and snap-judgment decisions for the orderly, deliberate and carefully digested jurisprudence of the land.

Correctives, he suggested, would be found through the influence and work of the Bar Associations, the U. S. Chamber of Commerce, and kindred bodies. But, he insisted, the greatest corrective force should be the body of young students who having been shown the truth, and having their broader duties defined, would go out into the world as a leavening and enlightening force.

Need I add that it is the germ of this thought which I would have the engineers inject into our engineering schools and societies as a primal function of the broader duty of the engineer?

If we turn to the pages of engineering history we open the book of inspiration; for we may profitably visualize and inquire into the spirit and purpose which animated the engineers of ancient Babylon and Ninevah, of ancient Ceylon, Madras, Arabia, and Southern Asia, of Greece and Rome, of Medieval Europe, and of the vigorous Renaissance of the 15th, 16th and 17th centuries. Can it be that the voice of the imposing engineering figures of those times was not heard throughout their respective countries? Were they dragged from the seclusion of their

cloisters by the politicians, or bashfully forced forward by the arm of necessity? Certainly not! They stepped, full-panoplied, into the arena of activity, and took the leadership. They had the bravery of conviction, and the temerity of knowledge; the vision of inspiration and the voice of prophesy.

The influence exercised by the ancient engineers upon the intellectual and material advancement of their times, the intimate and vitalizing direction which their genius inspired and the broader grasp of their duties enhanced, seem largely to have been lost sight of by historians. The writers of history appear to have sought too much for the romantic and epochal incidents which suited best the requirements of didactic epic or romantic prose. The substrata upon which human crises were founded, and the slow but necessary social and material processes by which the climacterics of the world were reached, have been treated with scant regard for the important part played by the engineering genius of all times.

While the achievements and traditions of the past are inspiring and romantic, yet the inspiration and romanticism of the present are even greater. The history of water works engineering, during the last century, is a record of achievement for the well-being, health and happiness of more millions than the combined military genius of all ages ever achieved.

The same overshadowing fact is equally true of the history of railroad building, the iron and steel industry, the mechanic arts, or of the whole realm of engineering activity, especially if viewed from the standpoint of the influence of the engineer upon public thought and happiness and if broadly visualized as we know it should be.

Must not these subjects fill the engineer with inspiration, enthusiasm and a deep conviction that he should make his voice heard and his influence more generally felt throughout the land than ever before? May he not feel himself the possessor of a rich, ennobling heritage? May he not go about his duties, however obscure they may be, or important, in a modest but secure consciousness that his profession, ministering as it does to human prosperity and happiness, is the noblest profession of them all? For, if engineering transmutes its collective genius into the monoliths of history, or the highways of continental conquest, or into the useful conversion of Nature's latent energies, though it

dwell among the humble, it will be given a seat among the mighty.

This is both the inspiration and the reward of the profession, and the call for us to visualize, sense and grasp the broader duties of the engineer.

THE ADMINISTRATION OF EUROPEAN CITIES.

By Julius Pitzman,*
Member of The Engineers' Club of St. Louis.
[Read before the Club, December 15, 1915.]

Note: I regret exceedingly that my trip was interrupted by the War, because I intended to use all my spare time in studying the Administration of European cities and the laws or ordinances so far as they refer to the organization of the cities and to the construction and maintenance of public works. As I was traveling with my wife and daughter, I could not do the work as carefully or systematically as I could have done otherwise, but, in the absence of a more complete report, it may be of interest to take a bird's-eye view.—Author.

LONDON.

After an automobile trip through the western part of England, we went to London, which city has a length of fourteen miles by a breadth of twelve miles, and has a population of over five million inhabitants. It is divided into twenty-eight districts and the central one, containing about one square mile, is known as the *City of London* and is located in the very heart of the larger City. It is governed by the Lord Mayor, twenty-five aldermen and a Court of Common Council. The other twenty-seven districts, known as "Boroughs," with the City of London, form an Administrative County, under Act of Parliament of 1888, and each Borough elects its Mayor and engineer. The Council, with the aid of experts and councilors, governs the cities and the British Mayor is wholly ornamental. Mr. George W. Humphrey is the present Chief Engineer of the Administrative County, but unfortunately he was absent from the City and I was prevented from obtaining the desired information, as none of the high officials under him were in town.

County Council.

The twenty-seven Boroughs are governed by a County Council, composed of one hundred and thirty-seven Members, one hundred and eighteen Representatives are elected every three years and the Members so elected appoint a sort of an upper House or Senate, consisting of nineteen additional Members, for a term of six years, but at the end of every three years one half of the Senators drop out.

The entire system of Administration of the City appeared so complicated, that it was impossible for me to get sufficient

*Consulting Engineer, St. Louis, Mo.

information, in the short time at my disposal, to give even a general idea of its city administration, but I will mention a few matters which may interest you. (If accurate information is wanted, I would suggest sending for a copy of "London Statistics 1912-1913," No. 1682, printed by King and Son.)

Buildings in London are erected under the Metropolitan Building Act and the law does not provide for the segregation of business houses from residences.

No property can be condemned for public uses, except with the consent of the owner, or under Act of Parliament, but in case of necessity, for sanitary purposes, proceedings of condemnation may be brought with the consent of the Minister of the Interior.

Public Utilities.

The sunken and elevated railroads are owned by private corporations, under Act of Parliament. The corporations pay to the City only the taxes on Stations, but nothing for the right of way over or under the streets. Fares for transportation are fixed by the corporations, under competition, and the government does not have to approve the rates. The usual charge is one penny (two cents) per mile in second class carriages and two pennies (four cents) per mile in first class carriages.

All tramways are owned by the public and controlled by the London County Council; charges are generally fixed by the rule of thumb.

The waterworks are owned by the City and operated under Act of Parliament by the Metropolitan Board. Water rates are fixed at five-per cent on ratable value of premises, others by meter rates. The charge is eleven pennies (twenty-two cents) for each 100 cu. ft. by those using one thousand to five thousand gallons, or six pennies (twelve cents) if consumer exceeds five million gallons.

The electric plants and conduits in thirteen Boroughs are owned by corporations and charges are regulated by competition, in the other fifteen Boroughs they are owned by the public. Licenses to operate plants are limited to seven years, but are extended usually for periods of seven years, but the Boroughs have the right to purchase such plants at market value.

Sewers and Streets.

The joint district sewers are built under the supervision of the Engineer of the London County Council and the district sewers are built by the borough engineers.

The grades of the streets are not established by legal proceedings and the streets are built at the expense of the abutting property owner, by the engineer of the Borough or by an engineer representing the owner.

The magnificent Victoria or Thames Embankment and its abutting park was built by the London County Council at public expense. The County owns the Embankment and some portions of the river front from which it collects revenue for the landing of boats, etc., but it has been thought advisable and to the best interest of commerce to leave the major part of the river front in the hands of private parties.

Taxes.

The taxes on land are based upon ratable value of real estate, inclusive of improvements, which is assumed at two-thirds of its rental value and not on saleable value of the premises, on which we in the States levy our general taxes. The County Council collects taxes only on lands and improvements and none on income or personal property. The rate of tax differs in the different Boroughs, but the average tax is seven and one half pence per pound of ratable value, being about three per cent on value.

Parks and Parkways.

The old and large parks are owned by the Government, the smaller ones by the County and some of the Boroughs.

The Mall, one of the great boulevards of London, leading from Trafalgar to Buckingham Palace, is two hundred feet wide by a length of about two-thirds of a mile, but it is not its width but the magnificent palaces on the sides and both ends that makes it an imposing boulevard. The northern fifty foot strip of the Boulevard is covered by the one story terrace attached to the renowned Carrolton House, the roof of which terrace is used for observing parades, etc.; next comes a sidewalk with a double row of trees 35 feet wide; a drive sixty-five feet wide; and another sidewalk adjoining St. James Park, fifty feet wide, total two hundred feet.

The larger portion of the streets of London are paved with asphaltum; then follows the brick, granite and wood paving; they are kept in perfect repair, immaculately clean and therefore it is not necessary to sprinkle them.

The City of London and the twenty-seven Boroughs each have their own mayor, engineer, etc., who attend to the work in their respective districts, but all work extending beyond the boundaries of a Borough is under the control of the County Council and the plans for new work in any Borough are subject to the approval of the County Council.

As the suffragettes of England declared war against the Government and had destroyed some historical paintings of great value prior to our arrival, the government ordered all museums and galleries closed. We therefore cut our visit short and went, by way of Dover and Calais, through the northern part of France and through Belgium to Holland.

The trip through the northern part of France and through the southern part of Belgium (the same district in which most of the fighting has been done) was delightful. All the fields were in the highest state of cultivation, the houses and barns of the farmers were built of brick and stone with tile or slate roofs and the county roads were in a better condition than those in the greater parts of our suburban districts.

BRUSSELS.

Our next stop was at Brussels, capital of Belgium, which has a population of nearly seven hundred thousand inhabitants, of whom about two hundred thousand live within the old part of the City, which was formerly surrounded by the old fortifications, five miles in length; said fortifications, however, were converted into magnificent boulevards in the early part of the Nineteenth Century. The old part of the City is surrounded by nine self governing suburban districts, covering an area of about four thousand acres; the built up portion is about three and five-eighths miles long by about two and three-eighths miles in width. Each of these municipalities, I was informed, is governed by a Burgomaster or Mayor, five Assessors (jurists) and a Municipal Council of twenty-nine members, elected for terms of six years.

The city owns most of its public utilities and derives a large profit from the operation of its gas plant, water works,

telephone and electric plants. The garbage is collected and reduced by the City, and the proceeds pay a large portion of the cost of operation. The revenue of the City is about ten million dollars and the indebtedness of the City, payable in 2003 is nearly sixty million dollars.

The central portion of the City is most interesting, as it contains many buildings of great historic value, dating back to the Fifteenth Century, and presents a most striking difference in comparison with our American cities. Buildings of historic value are preserved and maintained in first class condition, irrespective of any change in the surroundings, and I am inclined to think that the preservation of historic buildings helps to maintain the character of these sections of the City.

My last visit to Brussels was over forty years ago and, notwithstanding that the City has largely increased in size, the fine old homes that I saw at that time are now occupied by the same class of people and not a single house appears dilapidated or neglected. The streets and boulevards in these districts were simply extended and solidly built up to make room for the new comers.

Brussels is one of the wealthiest cities of the world, but it appears to me that the population is not sufficient to give life to the great number of wide drives and boulevards and in consequence of the introduction of the automobile and the tendency of spreading the City, the old part of the City may deteriorate in the near future.

AMSTERDAM.

After a few days in the beautiful and homelike city of Brussels, we made a brief stop at the Hague and then proceeded to Amsterdam, the Capital of Holland, which contains about six hundred thousand inhabitants. It is situated at the junction of the River Amstel with an arm of the southwestern part of the Zuider Zee, and was one of the members of the Hanseatic League.

Like Venice, it is built upon piles and in the central portion about one half of the width of each street is occupied by a canal with perpendicular retaining walls. On both sides of the canals are broad paved streets and sidewalks planted with handsome shade trees. The old small canals were built by the

City, but now the cost of similar canals is charged against the abutting property.

In 1825, the North Holland Canal, having a depth of sixteen feet, was built at an expense of $7,200,000, but in consequence of the construction of large steamers, it became necessary to build the North Sea Canal, having a length of fifteen miles, a depth of thirty feet and a breadth of from sixty-five to one hundred and ten yards. This canal was completed in 1876 at a cost of $16,000,000, exclusive of the cost of construction of massive locks and of four outlets at Ymuiden on the east shore of the North Sea, which were completed in 1895. The Merwede Canal, running via Utrecht and Lak to the Rhine, was built in 1892 and proved of great importance to the commerce.

All of these improvements were paid for out of the proceeds of bonds, sold with the consent of the Province, payable in fifty years, and bearing four per cent interest.

The City is built at an elevation which is below high tide; it is about one meter below the Zuider Zee and from two to three meters below the North Sea and the basins or central harbor built for sea going vessels contains five hundred and thirty acres.

The sewers in the old part of the City drain into the canals, but portions of the new City have been provided with a separate sewer system. In 1907, the City adopted a new plan for the discharge of sewage into the Zuider Zee some distance from the City. The fact that a part of the sewage flows into the canals is not very objectionable, because the sewage is let out only at night and a fairly swift current is created through the canals by opening the flood gates at either the Zuider or North Sea or by washing out the sewers with fresh water from the Merwede Canal, built in 1892.

The small canals in the streets, having a width of nearly one hundred and fifty feet, are only three and one-half feet deep and are used principally for the local delivery of freight to all parts of the City and you see large barges pushed along by two men and then unloaded in front of elegant residences. Goods, fuel, etc., are carried away by men with dog carts or push carts and very few teams are used for the delivery of freight. This method of transportation is so cheap that the railroads cannot compete.

The City is very closely built up, immaculately clean and not a single house appeared vacant or showed any signs of decay. Walking along the streets, you constantly see servants at work washing not only the windows but also the fronts of the houses. Labor is very cheap; the City pays $6.40 per week for common labor and $12.00 per week for mechanics.

I noticed that very few middle men are employed in Amsterdam, because most produce is brought by barges to the towns and sold direct by the producer to the consumer from the barge or from the paved space adjacent to the canal. Nearly all the windows in the dwellings are decorated with a profusion of beautiful flowers (which can be bought in pots at one to two cents apiece) which give to the City a charm of its own.

Most of the vacant land is owned by the City and is leased for terms of seventy-five years at four per cent on its value; the buildings are erected mostly by contractors or by companies specially organized. Buildings, in general, are much more substantial, ornamental and permanent than similar buildings in the United States. Under the provisions of recent laws, all new factories have to be built in specially designated districts.

As I did not find that many of the officers spoke English or German fluently, I was not able to get detailed information about the administration, but was told that Amsterdam was governed by the middle class, which was divided into groups; the wealthy merchants owning ships and controlling a good portion of the commerce of the world, being the most influential group, but the moderately wealthy middle class and the group of shop keepers hold the balance of power and each group insists and sees to it that its rights and interests are well guarded.

BREMEN.

Our trip from Amsterdam to Bremen, which is the second largest shipping harbor of Germany, was impressive. The yield of the fields along the railroad appeared to be nearly twice as large as that of our farms, and all houses, stables and railroad depots were well built and equally well maintained and the dilapidated frame stables, sheds and fences which we find in many of our farming districts are not to be found in these sections of Germany.

We spent Sunday in Bremen and had delightful walks and

drives. The railroad station is a magnificent building in the central part of the city and is separated by a public square from a cluster of six hotels, flanked on either side by a museum and a public building. The old part of the city was formerly surrounded by fortifications, which have been removed and have been converted into a beautiful central parkway.

The interior part of the city is closely built up and contains a great many buildings of historic value. The old Rathaus or City Hall is built in early Gothic style, surrounded by a large number of buildings highly decorative and very impressive. The newer part of the city has very fine residences and they are set off magnificently by a profusion of flowers, shrubs and trees.

It is a pleasure to see that the architects, in designing the buildings, always adopt styles of architecture and elevations in perfect harmony with adjoining buildings and they thereby obtain much better affects than we do in the United States with larger expenditures.

The honesty and integrity of the Bremen merchant is proverbial in Germany and I was told that in the early part of the last century it was the custom of the city to make an annual statement of the money required by the administration and that each citizen made a voluntary contribution in proportion to his income, that many paid sums in excess of their proportionate part and that very few failed to pay, notwithstanding the fact that the list of contributors was not published.

In 1865, a large tract of land near the City was donated to the City by a lady and, by voluntary subscription, money was raised to improve the park. Ever since that time sufficient amounts have been donated annually to maintain it in the most perfect manner and over one and one-half million dollars have been spent for its embellishment. Whenever young people of wealthy families marry, it is customary for the parents to make a substantial donation for the further improvement of the park and these methods have created a civic pride that is admirable.

HAMBURG.

From Bremen we went by rail to Hamburg, which, next to New York, is now reported to be the greatest shipping place

of the world. In 1912 it had a population of 1,006,748 inhabitants and with its suburb, "Altona," had 1,200,000 inhabitants.

General Description.

The residence and general business parts of the city are located on the north side of the River Elbe and have a front of about five miles by a depth of about three miles and the built up portion contains about fifteen square miles. In the central part of this district is a beautiful lake or basin divided into two parts by a magnificent bridge; the smaller basin is called the Inner Alster and contains about twenty acres, and the other portion, containing about two hundred acres, is known as the Outer Alster Basin. The Inner Alster is surrounded on three sides by magnificent hotels, restaurants, cafes, concert halls and elegant shops. The Outer Basin is surrounded by elegant suburban homes and embellished most profusely with flowers, trees and shrubs. There is a beautiful drive around the entire lake between these residences and the shore line and nearly all the land between the road and the lake and, appurtenant to the residences and on the other side of the drive, is laid out by experienced landscape gardeners and the boat and summer houses on the lake front add a great deal to the beauty of the landscape.

All the portions of the City that I have seen, except small portions within the lines of the former fortifications, were kept in perfect repair and I noticed hardly any for rent signs. The majority of the houses occupied by the laboring classes appeared to have been built especially for that purpose and the laboring people are much better housed in the large cities of Germany than ours in the States.

That part of Hamburg located South of the Elbe has a length of about seven miles by a width of about two miles; it contains about nine thousand acres, one-half of which area consists of canals and basins and the other half is mostly covered with railroads, warehouses, docks, quays, etc.

Annual Expenses of City Works.

The annual expenses of maintaining and developing the works of the City was sixteen and one-half million dollars in 1890, but has increased steadily and in 1911 reached the enormous sum of fifty-one million dollars, and I find that

nearly one-third of said sum is used annually for public buildings, statuary, fountains, etc., all of which of course add to the attractiveness of the City.

As it may be of interest to some of you gentlemen, I will quote the appropriation made for public improvements in 1911:

Street cleaning and sprinkling	$ 913,500
Maintenance of sewers	171,000
Extension of sewers	466,500
Construction of streets and repairs	2,212,500
River and harbor	4,935,000
Gas and electricity	3,375,000
Total	$12,073,500

That the expense for extension of sewers is rather small is to be attributed to the fact that all European cities are closely built up and the authorities do not permit the building up of districts before they are required for housing the increased population.

Local Government.

In 1860 a law was adopted creating a governing body consisting of a Senate of eighteen members and of a council of one hundred and sixty members (Buergerschaft). According to the provisions of the law, nine members of the Senate are selected from the legal fraternity, seven from the merchants or chamber of commerce and two from other vocations. After the formation of the German Empire in 1870, Hamburg surrendered its independence and was incorporated in the Empire, but the old organization of city government was continued.

The Senators hold their position for life and if a vacancy occurs, the Senate selects four men, the Council the same number, and the eight delegates select four and the four select two men (not from their own number) and these become candidates and are voted for at the following election. Every Senator so elected prepares a design for his coat of arms; his social position and that of his family is fixed permanently. The honor is so great that no citizen has ever refused the nomination, but a person seeking the office would stand a small chance of ever being elected. The nine Senators of the legal

fraternity, who have to give their entire time to the public, receive a salary of $7,500 and the other nine, who are permitted to continue in business, receive $3,750 annually. The Senate is an administrative and executive body and it represents Hamburg in all its transactions with the German Empire and exercises jurisdiction over the entire administration inclusive of the judiciary, but no act affecting the judiciary is ever passed unless approved by the four Syndici and the two Secretaries of the Senate, which six officers jointly with the eighteen Senators form the larger Senate.

Council.

The Buergerschaft or Council is a legislative body only. It consists of one hundred and sixty members, one half of whom are elected at large at intervals of three years. To prevent the Socialists from governing the City, a law was adopted for the selection of Members of the Council as follows: The property owners select forty, the notables, consisting of present and former members of the Senate, of the Members of the Council and of the Merchants Exchange, select forty and the rest of the voters select eighty; one-half of the members are required to reside in the North and one-half on the South side of the Alster. Every male citizen of the remaining population, who pays taxes on an income of three hundred dollars a year for five consecutive years, is entitled to a vote in the third class; all those that have a smaller income are considered paupers.

Mayors.

From the Senate, three men are selected to serve as mayors. The first and second mayors are executive officers and the third attends the meetings but continues his duties in the Senate as the representative of the two chief executive officers. The following year, the first mayor returns to the Senate, the second and third advance and a new one is selected to serve as third mayor and so on. With one exception, all of the mayors so far elected have belonged to the legal fraternity.

The salary of the mayors is $8,750 each, being an addition of one thousand dollars to the salary of a Senator.

Senate.

The Larger Senate consists of eighteen members as afore-

said, of four syndics and two secretaries. The last mentioned officers participate in the debates but have no vote.

The Senate designates, from amongst the one hundred and sixty members of the Council, those that are to serve in the following departments: Departments of Finance, Building, School, Police, Commerce and Marine, Water and Light, Courts and Military. Each department is presided over by one Senator and assisted by one or two and the rest of the board is made up from the representatives of the Council, recommended by said body and approved by the Senate, and of the chief technical officers or specialists of the respective departments.

Members of the Council hold office for six years, half being elected every three years; they serve without salary.

All laws require joint action of the Senate and Council. The executive power of the different branches of the government is vested in the Senate, assisted by deputies selected from the Council. All ordinances require the approval of the Council, which has only legislative powers.

Pensions.

All employees of the City or their families are entitled to pensions in case of sickness or death and the amounts are fixed by the Department of Finance, assisted by twenty members of the Council. The law provides that not more than five lawyers shall be permitted to serve on the Committee and each party is represented in proportion to its strength at the previous election.

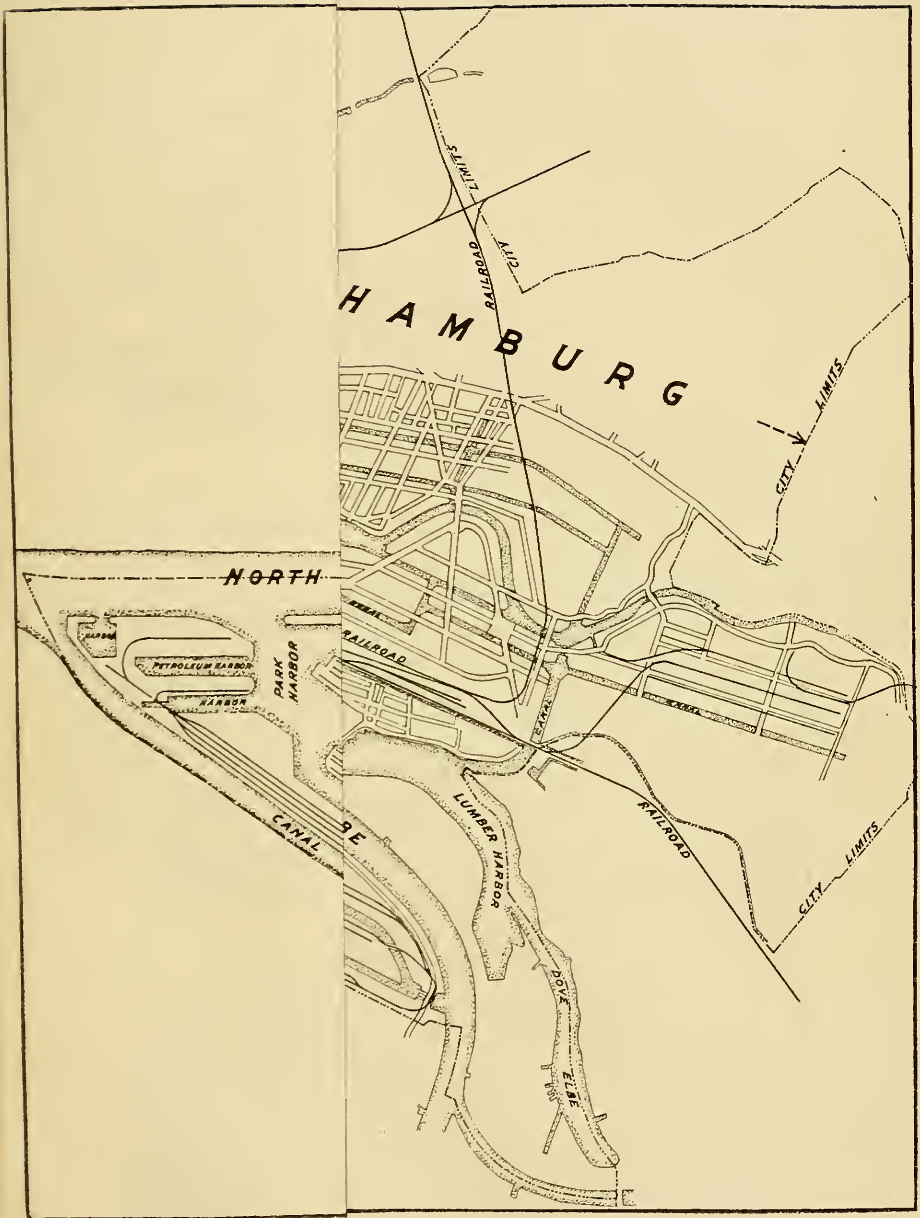
Land Values.

The land values in Hamburg are not as high as they are in the States and the general price paid for first-class business property is about $2,500 per foot for lots one hundred and fifty feet deep; the land for apartment houses is valued at one hundred dollars per foot and upwards; and for laborers' houses, from twenty-five to seventy-five dollars per foot in districts within a radius of half an hour's ride by the electric roads.

Revenues of City.

The running expenses of the government are paid out of the following sources:

Revenue from Incomes	$13,000,000
" " Real Estate	5,750,000
" " Rent of Property Owned	1,350,000


HAMBURG
RAILROAD
CITY LIMITS
CITY LIMITS
CITY LIMITS
NORTH
PARK HARBOR
PETROLEUM HARBOR
HARBOR
RAILROAD
CANAL
CANAL
CANAL
LUMBER HARBOR
RAILROAD
DOVE ELBE

THE HARBOR OF HAMBURG.

" " Lottery		1,050,000
" " Quay Tax		2,600,000
" " Stamp Tax		1,070,000
" " Imported Goods		1,980,000
Unearned Interest from Real Estate		600,000
Total		$27,400,000

The tax rate on incomes up to three thousand dollars is six per cent, above three thousand dollars it is seven and one-half per cent.

The annual expenses of the City, inclusive of betterments paid by bond issue, was $13,250,000.00 in 1890 and has been increased to $51,000,000.00 in 1912, being about three times the amount spent annually in St. Louis.

River Improvements.

The cost of the regulation of the Elbe and the construction of the harbors during the last sixty-five years amounts to over one hundred and fifty million dollars. Geheim Baurat Bubendey, an engineer of national reputation, who draws a salary of seven thousand dollars annually, is in charge and has sixty graduate engineers under him and about one thousand employees. To give you an idea of the magnitude of this department, I will cite in round figures the budget of 1914, which is as follows:

Salaries	$ 287,000.00
General expenses	200,000.00
Maintenance and operation	1,410,000.00
Extension of old work and purchases	303,000.00
Total	$2,200,000.00

The estimate of the annual new work in the harbor is four million and eight hundred thousand dollars, making a grand total of seven million dollars, which is two million dollars less than the amount spent in 1913. All expenses for operation and maintenance are paid out of the annual appropriation, but all extensions of the harbor are paid for by the sale of bonds, payable in fifty years, and bearing from three and one-half to four per cent interest.

The up-to-date improvements for shipping and for the transfer of freight has, within the last decade, caused Ham-

burg to supersede Liverpool and London and has enabled the Hamburg-American Line (which has for its motto, "My Field is the World") to supersede the English lines.

Hamburg owes its rapid increase and development to its location on the River Elbe, about sixty miles southwardly from the estuary at Cuxhaven on the North Sea. The river at Hamburg is nine and one-half meters deep at low tide and is now being deepened so as to have a depth of ten meters at low tide. The difference between high and low tide is two and eight-tenths meters at Cuxhaven and two meters at Hamburg.

The largest ships, such as the Imperator and the Vaterland, having a capacity of over 54,000 tons, unload at Cuxhaven and the passengers go either by boat to Hamburg or by rail direct to other places of destination. The entire river from Hamburg to the North Sea and the town of Cuxhaven are maintained and controlled by Hamburg.

Municipal Works.

The planning of the City and the constructing of sewers, streets and the supervision of buildings is in the hands of Baurat Merkel, who is also in charge of surveys, and Dr. Ingineer Ranke is "Chief of Hochbau," or the Building Department; both departments are closely connected and co-operate.

The laws regulating these departments are so different from ours that I will attempt to give a brief description by paragraphs.

Additions to City.

Lots are from thirty to fifty meters deep on an average, but no person is permitted to lay out his land into building lots unless the plan is approved by both departments, and if a person should attempt to lay out or improve his property without a permit, the City would not permit an outlet to or a connection with a public street.

Persons subdividing property must, in residence districts, set aside from twenty-five to thirty-three per cent thereof for streets, open places and for light and ventilation. No house over two stories in height can be built unless it connects with a sewer.

All streets are opened and improved by the Department, or by the owner with the approval of the Department, and as streets often cross lots diagonally, the owners of vacant

property can bring proceedings and force an exchange so as to diminish damages for opening of streets. All costs of openings are paid by the City, but subsequently included in the cost of the street improvement. The owners of lots on streets over seventeen meters wide have only to pay for an improvement of that width and the City pays the remainder out of public funds.

The City owns four tracts of forest land, containing about four square miles each, in close vicinity of Hamburg, which are being laid out for elegant homes. The sizes of these lots range from two-thirds of an acre to two and one-half acres, and no house can be erected covering over one-third of the area of its lot.

Building Commission.

In 1912, a committee consisting of two high technical officers, the Director of the Museum, director of Landscape Gardening, one artist, four architects and seven men of general culture, was appointed to approve plans and prevent the erection of unsightly buildings or such as would be an injury to the adjacent property. This committee determines the amount of damages to be paid to the owner, if changes are required to be made in the plan for the benefit of the public.

The Building Committee, consisting of two members of the Senate, five members of the Council, and the heads of the department, who have no vote, has to examine all plans for buildings and has to see to it that it is sanitary and well constructed. The law provides that all living rooms must be provided with light and air and an open space of two-thirds of the elevation of the house is required. No house can have more than five stories or be over twenty-four meters above the cellar floors, and an open space of one-half the height of the building must be left adjacent to every living room. The Commission also determines the front building line, the elevation of the basement floor, and also the general character of the front elevation of the entire block. After being perfected, the plans must be approved by the Senate, but minor changes may be made by the head of the department. Building inspectors see to it that all the plans and provisions are carried out.

Schools.

The schools are under the charge of a committee, composed of two Senators, ten representatives of the City Council, with four government counsels (Regierungsraetel), who are trained for this special purpose and who each receive a salary of $3,500 per year. When school houses are needed, this commission applies to the Building Department, stating the location and size required; the last mentioned department arranges for the acquisition of the property, prepares the plans and, if approved by the Committee, they are submitted to the Senate for final action.

Teachers of high schools begin on a salary of $1,125, which is gradually advanced to $2,750 in twenty years and at a certain age they retire with a pension.

Sewers and Streets.

All sewers are built and paid for by the City, but when completed the owners of the improved property have to pay about sixty marks per meter front, or about $4.60 per front foot; the owners of vacant lots pay five-twelfths of said sum, but as soon as the owner improves the lot he has to pay the other seven-twelfths. Lot owners pay the cost of all connections.

The minimum grade of all sewers is one per cent, unless they are provided with flushing tanks. Factories are not permitted to discharge hot water, having a temperature of over 37 degrees Celsius, unless a special permit is obtained.

When streets are improved, the owners of the improved property pay the cost, but the owner of unimproved property does not have to pay until he improves his lot and obtains a revenue or income therefrom. Owners can pay the cost in installments extending over flfty years, deferred payments bearing five per cent interest.

Water and Gas.

The City has purchased the water and gas plants and operates the same. Extensions are made free of charge. Lighting yields a net revenue of two million dollars and the water one-half million dollars. The electric current is furnished by a corporation, which pays a large revenue to the City for the privilege. Conduits are built three meters wide and two

meters in height under the sidewalks on both sides of the street in recent years.

Street Railroads.

The charters for street railroads were originally granted to private companies, but when the Socialists gained in power, they objected and claimed that the companies were making too large a profit; thereupon the City concluded to buy the street railroads, but, after a long debate, on motion of the engineers, it was decided to purchase only one-half of the stock. The engineers held that to operate a railroad, prompt action must be taken in emergencies and that better results could be obtained by leaving the administration in the hands of a corporation. All rules, regulations or plans for extension are now subject to the approval of the City officials, who also attend meetings of the directors, but the execution of the work and the operation is entirely in the hands of the corporation. The system has proved a great success, the City obtains a large revenue, and by controlling the street railways it can regulate the extension of the City.

As my party concluded to leave for Berlin, I called upon the heads of the departments to thank them for the courtesies extended to me and, when I asked one of those gentlemen whether their officers were placed under bond, he said: "We have no dishonest officers, and, if we should ever detect one, it will be better for the rich city of Hamburg to stand the loss than to require a bond and to cast suspicion upon men in high positions."

BERLIN.

The next day we proceeded to Berlin and to get a general view of the City, took an automobile trip through it. I was greatly impressed by the fine buildings erected there since my last visit and by the display of artistic statuary placed along the boulevards and along the Siegesalley (Lane of Victory) in the Thiergarten.

I made inquiry concerning the organization of the local government and found that it is not managed from one central station like our cities, but, like most large European cities, is composed of nineteen towns or municipalities, which have grown into one, each continuing its local self-government as a separate municipality.

Berlin has over two million inhabitants, and contains twenty-five square miles, or sixteen thousand acres. It provides for cleaning three hundred and sixteen miles of streets, containing sixteen hundred and eighty-six acres, costing over one million, five hundred thousand dollars per annum (wages average one dollar per day). The total city expenses in 1910 were $88,856,153. The bonded indebtedness increased from $31,540,401 in 1880 to $118,950,000 in 1910.

The Municipal Assembly.

The foundation upon which the government of the Prussian cities rests, is the Municipal Assembly, selected at a general election, at which everybody is entitled to a vote who pays an income tax of $218 or over, but the voters are divided into three classes with voting power in proportion to their income. To illustrate this, I quote from a book published by Price Collier (an American who has made a careful study of the German Government) who states the income of the citizens of Berlin to be as follows:

389,687	had	an	income	ranging	from	$ 218 to $ 25,000
521	"	"	"	"	"	$ 25,000 to $ 62,500
139	"	"	"	"	"	$ 62,500 to $125,000
22	"	"	"	"	"	$125,000 to $187,000
19	"	"	"	"	"	$187,000 to $250,000
19	"	"	"	"	"	$250,000 or more.

Based on these incomes, one-third of the Council in 1910 was elected by one hundred and thirty-one votes, one-third by 32,131 votes, and one-third by 357,345 votes, and as a result of this classification, only thirty-eight Social Democrats were elected to the Council, consisting of one hundred and forty-four members; 33,162 votes (being one-tenth of all voters) elected two-thirds of the Council and gained control of the municipal affairs of the City.

As a further protection against unfair legislation, power is given the King of Prussia to dissolve the Council by royal decree.

Collier states, in his book, "Germany and the Germans," "Prussia is a highly centralized government and what takes place in Prussia would certainly not take place in the States or in England;" he states that they have a patriarchal rule, coupled with the most successful social legislation, most suc-

cessful state control of railways, mines and other enterprises and that its industrial development, during the last quarter of a century is second to none; he further states that the Germans believe in an aristocracy of Kultur with a right to rule.

Schoenberg.

Schoenberg is one of the largest and wealthiest of Berlin's municipalities and the Council is elected in the manner previously described. It is composed of thirty-six members and selects the Magistrate in which the executive power is vested.

The Magistrate in Schoenberg is composed of two Mayors (smaller municipalities have only one), one Baurat, who has special charge of overhead construction, one Baurat, who has special charge of street and underground work, two legal advisors or councillors, one financier, and one physician or sanitary officer. All of the above mentioned officers are taken from a list of men who specialize in municipal work, and are not required to be citizens of Berlin. The Council furthermore selects twelve of their number who participate in meetings, but they serve without pay. All estimates for work are prepared by the Magistrate, but have to be submitted to the Municipal Assembly for approval.

As the Mayor of Schoenberg is a brother-in-law of Mr. Otto Schmitz, my chief of office for over thirty years, I enjoyed special privileges in securing all the information I desired.

Sewers.

Inquiring about the sewer system, I found that it was built and paid for by the City on a tax of slightly over five dollars per front foot, which is levied on all lots which are built upon, and the same amount is paid by the owner of a vacant lot as soon as improvements are erected which produce a revenue. The owner has to pay for the connection and ten per cent for designing and superintending. The sewage is pumped onto large fields which are rented to gardeners, and I was told that the health of the people working in these fields is just as good as those occupying houses up town. For maintenance of the sewer system, the City collects two per cent of rentals. The regulations forbid the discharge into the sewers of certain acids or of water having a temperature of over 35 degree Celsius.

The building ordinance forbids the erection of buildings on unimproved streets or on streets not built with the approval of the Magistrate, unless a special permit is obtained.

Persons laying out additions to the City have to build, with the approval of the Department, substantial streets, provide for illumination and pay the cost of maintenance for five years. If streets have a width of over twenty-six meters, or say eighty-five feet, the City pays the excess cost. No street is permitted to be built unless it is in continuation of an existing improved street.

If the City builds a street on its own motion, it pays the cost and collects the proportionate part from the respective owners, inclusive of the cost of maintenance for five years, as soon as the property abutting such street is improved and pays a revenue. The Magistrate can forbid the construction of a new street. In determining the cost, the land required is included, but persons who have previously opened such streets, receive credit for the value of the land given. The cost of bridges is also included.

A HASTY RETREAT.

As I had taken up a great deal of time of His Honor, the Mayor, and as a great many of his officials were absent on summer vacations, I stopped further inquiry and made an appointment for the latter part of the week, but Friday came and with it the Declaration of War. As my wife and daughter were not as anxious as I to see the mobilization of the army, we beat a hasty retreat to Antwerp and managed to pick up passage on the Red Star Line for Boston.

Our trip through the English Channel, three days after the Declaration of War, was rather exciting as the Channel was crowded with English men-of-war and we were escorted by the pilots to avoid the mine fields. On the open sea we were stopped almost daily by warships and even within five miles of Boston we were halted and examined.

If, owing to the limited time at my disposal, inaccuracies have slipped in, I wish to apologize. To those who specialize in Municipal Engineering, I will be pleased to loan my two volumes of "Hamburg and Its Works," published since the outbreak of the war and sent to me by the Chief of Engineers.

ASSOCIATION

OF

ENGINEERING SOCIETIES

Vol. 55. JULY and AUGUST, 1915. No. 1

PROCEEDINGS.

The Engineers' Club of St. Louis

The 817th meeting of the Club was held Wednesday, June 9, 1915, at 8:15 p. m., as a Joint Meeting of the Associated Engineering Societies of St. Louis under the auspices of the St. Louis Branch of the American Society of Engineering Contractors. The meeting was called to order by President J. W. Woermann, who called upon Mr. J. T. Garrett, of the A.S.E.C. to preside. The total attendance was 46.

The minutes of the 11th, 12th and 13th Joint Meeting of the Associated Societies were read and approved.

The presiding officer presented Mr. J. B. Emerson, of the Robert W. Hunt & Co., who read a paper on "Needed Improvements in Specifications," which was followed by discussion.

Dr. G. R. Olshausen, of the U. S. Bureau of Standards, Washington, D. C., gave an interesting outline of the tests he is making on full size columns for the Am. Soc. C. E., and the American Railway Association.

Adjourned 10:30 p. m.

JOSEPH W. PETERS, *Assistant Secretary.*

The 818th meeting of the Club was held Wednesday, June 16, 1915, at 8:15 p. m., as a Joint Meeting of the Associated Engineering Societies of St. Louis, under the auspices of the St. Louis Branch of the American Society of Mechanical Engineers. President John W. Woermann called the meeting to order and then called upon Mr. Edward Flad, Chairman of the St. Louis Branch of the A.S.M.E. to preside. The total attendance was 45.

The minutes of the 14th Joint Meeting were read and approved.

The Committee composed of Messrs. J. A. Ockerson, M. L. Holman, Edward Flad, H. H. Humphrey and E. L. Ohle, appointed at the 6th meeting of the Joint Council to investigate the report of the Missouri Senate Water Power Commission in reference to the proposed project to connect the Missouri and Meramec rivers by means of a canal to develop hydroelectric power, announced that their report was ready. Mr. E. L. Ohle read the report.

Motion made and unanimously carried that the report as read be accepted and made a part of the minutes.

Motion made and unanimously carried that the data contained in said report be given to the public press.

Mr. Flad presented Mr. E. R. Fish, Vice-President and Secretary of the Heine Safety Boiler Co., and past president of the Engineers' Club, who read a paper on "Boiler Failures and What the A.S.M.E. is Doing to Prevent Them." A number of stereopticon views were shown and discussion followed.

Adjourned 10:45 p. m.

JOSEPH W. PETERS, *Assistant Secretary.*

The 819th meeting of the Club was held Saturday, June 26, 1915, as a Joint Inspection trip of the Associated Engineering Societies of St. Louis, under the auspices of the St. Louis Branch of the American Society of Mechanical Engineers. The total attendance was 85.

The party left the Union Station at 1:15 o'clock for Valley Park, Mo., where they were shown through the works of the St. Louis Plate Glass Co. The trip proved to be one of exceptional interest and was thoroughly enjoyed.

JOSEPH W. PETERS, *Assistant Secretary.*

The 820th meeting of the Club was held Saturday, July 10, 1915, as an Inspection Trip of the Mill Creek Joint District Sewer by the Associated Engineering Societies of St. Louis, under the auspices of the St. Louis Association of members of the Am. Soc. C. E. The total attendance was 40.

The party gathered at the City Office, 1127 Armstrong avenue, at 2 o'clock, where they were furnished with rubber boots and slickers, which were loaned to the Club by the U. S. Engineer Office and the City. The party formed into two groups and was taken through the work by City Engineers and the contractors. Several shafts were entered and the different stages of the work inspected.

The trip proved to be an exceptional opportunity to view this class of work on a large scale within the city and it was regretted that a larger number did not attend.

The trip was finished about 4:30 o'clock.

JOSEPH W. PETERS, *Assistant Secretary.*

Association of Engineering Societies

Vol. 55. OCTOBER, 1915. No. 3

PROCEEDINGS.

The Engineers' Club of St. Louis

The 821st meeting of the Club was held Friday, July 23, 1915, 8:30 p. m., on the excursion steamer Alton on the Mississippi River. Members of the Associated Engineering Societies and St. Louis Railway Club were invited to attend. The total attendance was 440.

Dancing was the popular feature of the evening. In addition to the boat orchestra the Entertainment Committee had present part of the Mandolin Club of Washington and also jubilee singers. Refreshments were served gratis by the Club.

The boat returned at 11:00 o'clock.

Joseph W. Peters, *Assistant Secretary.*

The 822nd meeting of the Club was held in the Club Rooms, Wednesday, September 8, 1915, at 8:15 p. m., as the reunion meeting following the summer vacation. President J. W. Woermann opened the meeting and after a few remarks on the occasion called upon First Vice-President W. E. Rolfe to preside. The total attendance was 96.

The program consisted of short talks on observations and experiences en route and at the Panama-Pacific and San Diego Expositions, accompanied by stereopticon and motion pictures. Messrs. O. F. Harting, C. M. Talbert, John Hunter, E. R. Kinsey, W. E. Rolfe and J. W. Booth of the Missouri Pacific Railway addressed the Club.

A rising vote of thanks was extended the speakers, after which the usual collation was served in the Library.

Adjourned 11:15 p. m.

Joseph W. Peters, *Assistant Secretary.*

The 823rd meeting of the Club was held in the Club Rooms, Wednesday, September 15, 1915, at 8:15 p. m., President J. W. Woermann presiding. The total attendance was 30.

Motion made and carried that the minutes of the 816th to 821st meetings be approved as printed in the Journal. The minutes of the 822nd meeting were read and approved.

The minutes of the 569th, 570th, 571st and 572nd meetings of the Executive Committee were read.

The President presented Mr. Emil N. Tolkacz, Director of Public Welfare, City of St. Louis, who delivered an exceptionally interesting talk on the problems before the Department of Public Welfare and discussed the needs to secure the future welfare for the City of St. Louis. A brief discussion followed.

A rising vote of thanks was extended Mr. Tolkacz.

Adjourned 10:15 p. m.

Joseph W. Peters, *Assistant Secretary.*

The 824th meeting of the Club was held in the Club Rooms, Wednesday, September 22, 1915, at 8:15 p. m., President J. W. Woermann presiding. The total attendance was 51.

The minutes of the 823rd meeting were read and approved.

The presiding officer presented Mr. John E. Conzelman, Vice-President and Chief Engineer of the Unit Construction Company, who read the paper of the evening, entitled, "Recent Applications of Unit Methods to Reinforced Concrete Construction." Mr. Conzelman showed a large number of lantern slides illustrating the application of unit methods to various types of structures with particular reference to the hydroelectric development at Cedars, Province of Quebec, Canada. A brief discussion followed.

Mr. Baxter L. Brown read the following resolution, which, after a brief discussion, was unanimously adopted:

> Whereas: There exists a popular demand for motion pictures in addition to stereopticon views in illustrating engineering construction and industrial operations, as well as for entertaining features; and
>
> Whereas: Motion pictures are adaptable to technical and educational work, as evidenced by their increasing utility; and
>
> Whereas: Motion picture films of appropriate character can be borrowed or rented at a nominal cost; and
>
> Whereas: A motion picture projector would incorporate all the features of our stereopticon without additional cost of operation; and
>
> Whereas: The use of motion pictures would offer particular advantage to our Entertainment and Meetings and Papers Committees in presenting a more diversified and entertaining program, thereby increasing the attendance at the Club meetings:
>
> Therefore, Be It Resolved: That the members of the Engineers' Club of St. Louis be requested to voluntarily contribute one dollar ($1.00) each toward establishing a fund from which a motion picture projector can be purchased.
>
> Resolved, Further: That the President appoint a committee to receive the money contributed, investigate and purchase a machine with appurtenances and transact any other business in this connection and report to the Executive Committee.

Adjourned 10:30 p. m.

Joseph W. Peters, *Assistant Secretary.*

The 825th meeting of the Club was held in the Club Rooms, Wednesday, September 29, 1915, at 8:15 p. m. President J. W. Woermann called the meeting to order and after the reading and approval of the minutes of the 824th meeting of the Club, called on Past-President J. D. von Maur to preside. The total attendance was 85.

The papers and talks of the evening were on the Elimination of the Tower Grove Grade Crossing. Mr. S. L. Wonson, Bridge Engineer for the Missouri Pacific Railway Company; Mr. Perry Topping, Assistant Engineer for the St. Louis & San Francisco Railway Company, and Mr. L. R. Bowen, Bridge Engineer for the City of St. Louis, collaborated on the interesting features in the design and construction of this viaduct. The subject was illustrated by a large number of stereopticon views. Supplementary brief talks were made by Messrs. C. E. Smith, P. W. Connelly and E. D. Smith.

Adjourned 10:30 p. m.

Joseph W. Peters, *Assistant Secretary.*

Association of Engineering Societies

Vol. 55. **NOVEMBER, 1915.** No. 4

PROCEEDINGS.

The Engineers' Club of St. Louis

The 826th meeting of the Club was held in the Club Rooms, Wednesday, October 13, 1915, at 8:15 p. m., President John W. Woermann in the chair. The total attendance was 77.

The minutes of the 825th meeting of the Club were read and approved.

The minutes of the 573rd meeting of the Executive Committee were read.

Two letters, one from Prof. A. S. Langsdorf, presenting his new book on "Principles of Direct Current Machines," to the Club library, and one from Mr. E. H. Tenney, presenting his new book on "Test Methods for Steam Power Plants," to the Club library, were read. Motion unanimously carried that a vote of thanks be extended to the authors of these two books.

Past President A. S. Langsdorf took the chair at the invitation of President Woermann.

The following amendments to the Constitution were unanimously proposed:

Amend Article III, Section 1, to read as follows:

> Section 1. The officers of the Club shall be a President, three Vice-Presidents, a Secretary, a Treasurer, a Librarian, and three Directors. These officers shall be chosen in the manner prescribed by the By-laws, and shall hold their offices for one year, or until their successors are duly installed. Vacancies shall be filled at the first meeting after they occur.

Amend Article V, Section 1, line 2, by striking out the words, "in December," and adding, *after January 3rd.*

The amended section will then read as follows:

> Section 1. The annual meeting of the Club will be held on the evening of the first Wednesday after January 3rd. Other meetings may be held at such times as the Club may appoint. Meetings may be called at any time by the Executive Committee or by the President upon the request of three mmbers.

Amend Article V, Section 2, to read as follows:

> Section 2. At the annual meeting reports shall be presented by the Executive Committee through the President; by the Secretary, Treasurer, Librarian and various Committees of the Club. After the presentation of the annual reports, the newly elected officers will be installed.

The following amendments to the By-laws were unanimously adopted:

Amend Section 6 by adding, *The fiscal year of the Club shall coincide with the calendar year.*

The amended section will then read as follows:

> Section 6. Treasurer.—The Treasurer shall collect all moneys due the Club, be custodian of all its funds, and pay such bills against the Club as the Executive Committee shall approve. The Treasurer shall deposit the moneys and invest the funds of the Club in its name and with the advice of the Executive Committee. The fiscal year of the Club shall coincide with the calendar year.

Amend Section 12 to read as follows:

> Section 12. Nomination of Officers.—At the first meeting in November of each year, the members present shall elect by ballot four members of a Nominating Committee, at least one, but not more than two of whom, shall have been members of the Nominating Committee of the preceding year. These four members, with the last living past president as chairman, shall constitute the Nominating Committee. In case of inability of any of the above members to serve, substitutes shall be appointed by the Executive Committee before November 15th. The Nominating Committee shall select one or more candidates for each office to be filled for the ensuing year, and report to the Club at the first meeting in December, when the names proposed shall be placed in nomination. A copy of the report of the Nominating Committee shall be mailed to each member of the Club not less than two days prior to the first meeting in December. Additional nominations for any office may be made at this meeting by written petition signed by ten members. On the ballots for the election of officers, the names of the candidates for each office shall be listed alphabetically.

The suggestion of the Executive Committee, that the Club, in accordance with Section 4 of the By-laws, authorize the Executive Committee to appoint a Secretary for one year at a salary to be fixed by the Club, upon the recommendation of the Executive Committee, was unanimously approved.

The Chairman called upon Prof. E. L. Ohle, of Washington University, who presented an illustrated report on Devices for Smoke Abatement, with Particular Reference to Tests Made at Washington University on Two House-heating Furnaces. Following Prof. Ohle, Mr. W. A. Hoffman, Inspector of Boilers, Elevators and Smoke Abatement of the City of St. Louis, read an illustrated paper on Recent Boiler Installations and Some Results of Furnace Investigations. A brief discussion followed.

Adjourned 10:20 p. m.

Joseph W. Peters, *Assistant Secretary.*

The 827th meeting of the Club was held Wednesday, October 20, 1915, with the Club as host at an informal dinner and theater party to the visiting guests of the St. Louis Section of the American Institute of Electrical Engineers during their two-day meeting here in commemoration of the one hundredth meeting of the St. Louis Section. Dinner was served at the American Hotel Annex at 6:30 p. m., after which the party went to the Columbia Theater. Members of the Associated Societies were invited. The total attendance was 62, of which 29 were guests.

JOSEPH W. PETERS, *Assistant Secretary.*

The 828th meeting of the Club was held Saturday, October 23, 1915, as an inspection Trip to the new By-Product Coke Oven Plant of the Laclede Gas Light Co., by the Associated Engineering Societies of St. Louis, under the auspices of the Engineers' Club. The total attendance was 120.

Four parlor cars were furnished by the Laclede Gas Light Co., which left Eighth and Pine streets at 1:30 o'clock. At the plant was viewed the latest methods of storing and preparing coal, the manufacture of coke on a large scale and the treatment of gas for the recovery of the by-products, etc. After the party had been taken through the plant by guides, they were served a light luncheon.

JOSEPH W. PETERS, *Assistant Secretary.*

The 829th meeting of the Club was held in the auditorium of the Soldan High School, Tuesday, October 26, 1915, at 8:15 p. m., as a Joint Meeting of the Associated Engineering Societies of St. Louis, under the auspices of the St. Louis Branch of the A.S.M.E. A number of local organizations were invited to attend. The total attendance was estimated at 1,200. Mr. Edward Flad presided.

Dr. John A. Brashear, President of the American Society of Mechanical Engineers, delivered an illustrated lecture on "The World's Great Telescopes and Discoveries Made by Their Use."

Following the meeting an informal reception was held in honor of Dr. Brashear.

Adjourned 10:15 p. m.

JOSEPH W. PETERS, *Assistant Secretary.*

The 830th meeting of the Club was held in the Club Rooms, Wednesday, November 3, 1915, at 8:15 p. m., President John W. Woermann presiding. The total attendance was 75.

The minutes of the 826th, 827th, 828th and 829th meetings of the Club were read and approved.

In accordance with Section 12 of the By-laws, the members present elected the following Nominating Committee: Messrs. John Hunter, E. R. Kinsey, Herman Pfeifer and G. M. Curry. Past President A. P. Greensfelder, in accordance with the By-laws, acts as Chairman of the Committee.

President Woermann asked for an expression of opinion from those present as to the desirability of having a course of lectures on Military Engineering delivered before the Club. About 75 per cent of those present voted in favor of such lectures.

President Woermann explained the unavoidable absence of Mr. F. G. Jonah, Chief Engineer of the St. Louis and San Francisco Railroad, who was to have presented his paper before this meeting, and introducd Mr. H. E. Burns, assistant to Mr. Jonah, who read the paper for him, entitled, "Suggested Improvements in the Terminal Situation in St. Louis." The paper was profusely illustrated by maps and photographic slides. Discussion followed, participated in by Messrs. B. L. Brown, H. Pfeifer, Col. Townsend, C. S. Butts, S. W. Bowen and E. R. Kinsey. Suggestions were made that the paper be published in the Journal and further discussion invited.

Adjourned 10.45 p. m.

JOSEPH W. PETERS, *Assistant Secretary.*

Association of Engineering Societies

Vol. 55. DECEMBER, 1915. No. 5

PROCEEDINGS.

The Engineers' Club of St. Louis

The 831st meeting of the Club was held in the Club Rooms, Wednesday, November 10, 1915, at 8:15 p. m., as a Joint Meeting of the Associated Engineering Societies of St. Louis, under the auspices of the St. Louis Section of the American Institute of Electrical Engineers. President John W. Woermann called the meeting to order. The total attendance was 49.

After the reading of the minutes the Secretary read a resolution addressed to the Engineers' Club, adopted at the final session of the 314th meeting of the American Institute of Electrical Engineers, held at the Planters' Hotel, October 19 and 20, 1915, expressing thanks and appreciation of the services rendered and the hospitable manner in which the visitors were entertained.

President Woermann called upon Mr. S. N. Clarkson, Chairman of the St. Louis Section of the A. I. E. E. to preside. Mr. Clarkson expressed thanks on behalf of the St. Louis Section for the aid of the Engineers' Club in making the session of the 19th and 20th a success, and presented to the Club a framed photograph of the members and guests atending that meeting.

Following the routine business before the St. Louis Section of the A. I. E. E., the presiding officer introduced Mr. C. J. Carlsen, of the Commonwealth-Edison Co., of Chicago, who presented an illustrated paper on "The Use of Electricity in the Manufacture of Ice." Discussion followed.

Adjournment, 10:30 p. m.

Joseph W. Peters, *Assistant Secretary.*

The 832nd meeting of the Club was held in the Club Rooms, Wednesday, November 17, 1915, at 8:15 p. m., First Vice-President, W. E. Rolfe presiding. The total attendance was 85.

The minutes of the 830th and 831st meetings of the Club were read and approved and the minutes of the 574th meeting of the Executive Committee were read.

The papers of the evening were on the Mill Creek Sewer Design and

Construction. Mr. W. W. Horner, Engineer in Charge of Design, Sewers and Paving, City of St. Louis, gave a brief history of the sewer system of St. Louis and particularly that for the Mill Creek Valley. He made a comparison of the old and new methods of design and outlined studies of the several routes for the new Mill Creek Relief Sewer and discussed the adopted plan. The Chairman explained the unavoidable absence of Mr. Clinton H. Fisk, Chief Engineer, Construction Sewers and Paving, City of St. Louis, who was to have presented his paper before this meeting, and introduced Mr. Harvey S. Owen assistant to Mr. Fisk, who presented the paper for him, which dealt with the construction of the sewer. Following Mr. Owen, Mr. R. C. Gans, one of the engineers on this work, read a short paper on the arrangements for carrying the alignment. The papers were profusely illustrated by stereoptican views.

Adjourned, 11:00 p. m.

Joseph W. Peters, *Assistant Secretary.*

The 833rd meeting of the Club was held in the Club Rooms, Wednesday, November 24, 1915, at 8:15 p. m., as a Joint Meeting of the Associated Engineering Societies of St. Louis, under the auspices of the St. Louis Association of Members of the American Society of Civil Engineers. Mr. Edward E. Wall presided. The total attendance was 125.

The minutes of the last joint meeting were read and approved.

Mr. Wall introduced Admiral H. R. Stanford, U. S. N., Chief of the Bureau of Yards and Docks, who presented the paper of the evening on "The Pearl Harbor Dry Dock." The paper was illustrated by stereoptican views and several models. A brief discussion followed.

A rising vote of thanks was extended the speaker.

Adjourned, 10:45 p. m.

Joseph W. Peters, *Assistant Secretary.*

The 834th meeting of the Club was held in the Club Rooms, Wednesday, December 1, 1915, at 8:15 p. m., as a Joint Meeting of the Associated Engineering Societies of St. Louis, under the auspices of the St. Louis Branch of the American Society of Engineering Contractors. President John W. Woermann called the meeting to order. The total attendance was 47.

The minutes of the last Joint Meeting were read and approved.

The following report of the Nominating Committee of the Club was read:

President	F. E. Bausch
First Vice-President	H. I. Finch
Second Vice-President	F. G. Jonah
Third Vice-President	J. T. Garrett
Treasurer	F. T. Cutts
Director	W. E. Rolfe
Director	O. F. Harting
Director	W. O. Pennell

"Due to several changes effective for the first time during the coming year, such, that a Secretary be appointed instead of elected; that an additional Vice-President and Director are added to the Executive Committee; that the Board of Managers of the Journal is dissolved, we are abiding by the proposed amendment to the by-laws, approved by the Legislative Committee and printed in the November issue of the Bulletin. Under this arrangement the offices of Secretary and Librarian are consolidated; the names and duties of the standing committees have been re-arranged and the editing of the proposed journal of the St. Louis Club will be taken care of by one of the proposed committees."

Respectfully submitted,

A. P. Greensfelder, John Hunter, G. M. Curry, E. R. Kinsey, H. J. Pfeifer.

President Woermann called upon Mr. J. T. Garrett, Chairman of the St. Louis Branch of the A. S. E. C., to preside. Mr. Garrett presented Mr. H. F. Hackedorn, President of the American Society of Engineering Contractors and President of the Hackedorn Contract Co., of Indianapolis, Ind., who read the paper of the evening, entitled, "Equitable Specifications and Contracts." An interesting discussion followed.

Adjourned, 10:30 p. m.

JOSEPH W. PETERS, *Assistant Secretary.*

The 835th meeting of the Club was held in the Club Rooms, Wednesday, December 8, 1915, at 8:15 p. m., as a Party Meeting with and under the auspices of the St. Louis Section of the American Institute of Electrical Engineers. Mr. S. N. Clarkson presided. The total attendance was 59.

Mr. W. L. Berry, Industrial Engineer, Union Electric Light & Power Co., read an illustrated non-technical paper on "The Electric Steel Furnace," which was followed by a brief discussion.

Announcement was made that Mr. W. O. Pennell was elected chairman and Mr. George McD. Johns, Secretary of the St. Louis Branch of the A. I. E. E. for the ensuing year.

Adjourned 10:15 p. m.

JOSEPH W. PETERS, *Assistant Secretary.*

The 836th meeting of the Club was held in the Club Rooms, Wednesday, December 15, 1915, at 8:45 p. m., after adjournment of a Joint Meeting of the Associated Engineering Societies of St. Louis, at which the proposed revision of the Joint Regulations was adopted. President John W. Woermann presided. The total attendance was 55.

The minutes of the 835th meeting of the Club were read and approved and the minutes of the 575th meeting of the Executive Committee were read.

The report of the St. Louis Members of the Board of Managers of the Association of Engineering Societies setting forth the activities during the past year and giving the present status of the Association, recommending that the Association be disbanded on December 31, 1915, and that the money remaining after paying all obligations be divided pro

rata according to the number of subscribers in each society, was unanimously adopted.

The recommendation of the Executive Committee. in view of the proposed disbanding of the Association of Engineering Societies on December 31, 1915, and the discontinuance of the publication of its Journal, that the Club publish a bi-monthly journal, to be known as the Journal of the Engineers' Club of St. Louis. beginning in January, 1916; the setting aside of an allotment of $2.50 per member per annum for that purpose; the establishment of a price of $2.00 per member per annum for independent subscribers. with single copies at thirty-five cents; the additional funds necessary to be secured from advertising, was moved and unanimously carried.

The recommendation of the Executive Committee that Joseph W. Peters, appointed Secretary of the Club for the year 1916, be paid a salary of $125.00 per month, 10 per cent on Journal advertising, and remission of dues and incidental expenses, was moved and unanimously carried.

The President called for the reading of the proposed amendment to Section 7 of the By-laws. After the reading of the proposed amendment, Mr. W. E. Rolfe offered the following amendment: "Strike out the first sentence in the second paragraph as printed in the Bulletin and substitute the following: "The President shall appoint the chairman of the standing committee in January. The chairman shall report to the Executive Committee when so instructed and to the Club at the annual meeting." After some discussion this amendment to the amendment was unanimously adopted, after which the amendment as amended was unanimously adopted. Section 7 of the By-laws will now read as follows:

> Sec. 7. STANDING COMMITTEES.—Standing committees of the Club shall, in addition to the Executive Committee, include the following: PROGRAM. to provide programs, secure papers and arrange for inspection trips; MEMBERSHIP, to recommend and secure new members and serve as a reception committee at meetings; HOUSE AND LIBRARY, to have charge of and maintain the Club quarters and library, make recommendations for improvements and enlargements and supervise all changes and additions approved by the Executive Committee; ENTERTAINMENT, to provide entertainment and refreshments and arrange social functions; PUBLISHING. to edit and issue all publications and arrange for publicity of Club activities; PROCEDURE, to recommend revisions of the constitution, by-laws and rules of order; CIVIC. to ascertain the Club's interest in civic matters and make recommendations concerning endorsement of or participation therein.
>
> The President shall appoint the chairman of the standing committees in January. The chairmen shall report to the Executive Committee when so instructed and to the Club at the annual meeting. Each chairman. in conjunction with the President, shall select at least four other members of the Club to serve for the current year on that committee, two of whom shall have served on the committee the preceding year. He shall designate one member of the committee as vice-chair-

man, who, in his absence, will meet but not vote with the Executive Committee.

Members may serve on more than one committee. Duties of the standing committees may be readjusted, increased or combined by the Executive Committee at any time. Additional committees may be appointed when recommended by the Executive Committee or the Club.

The President then asked if there were any additional nominations for officers for 1916. The Assistant Secretary read a petition nominating Mr. E. D. Smith for President, signed by 116 members of the Club. Mr. Smith's name was ordered placed in nomination.

Letters were read from Messrs. M. L. Holman, V. K. Hendricks, and Julius Pitzman, donating books to the Club library, and from H. J. Elson donating $5.00 to the Motion-picture Fund. Motion was unanimously carried instructing the Secretary to write letters of thanks to the donors on behalf of the Club.

The President then called on Mr. Julius Pitzman, who read a very interesting and instructive illustrated paper on the Administration of European Cities, with particular reference to the cities of London, Bremen, Hamburg and Berlin. Prof. C. A. Waldo and Messrs. C. E. Smith, J. H. Bernhard, W. Harding Davis and others, brought out interesting points in the discussion which followed.

Adjournment at 11:00 p. m.

JOSEPH W. PETERS, *Assistant Secretary.*

The Oregon Society of Engineers

Thursday, November 18, 1915, at 6:00 p. m., The Oregon Society of Engineers held a meeting in the main dining-room of the Commercial Club.

After an hour spent in getting better acquainted with ourselves and each other in the Green Room, about 65 members and guests proceeded to the eighth floor, where dinner was served. The dining-room was provided with desks and other school-room furnishings, and seldom has a teacher had a more unruly group of pupils than did Mr. J. A. Fouilhoux, who attempted to instruct his classes in some of the elementary principles.

Following the dinner and a half hour of schoolday stunts, President Wm. S. Turner introduced Mr. J. C. Ralston of Spokane, who spoke at length upon the "Broader Duties of the Engineer." At the close of Mr. Ralston's address, Mr. W. H. Graves moved that a vote of thanks be extended to Mr. Ralston for coming to Portland and speaking before us. This was carried unanimously.

Mr. Samuel C. Lancaster spoke briefly about the Columbia River Highway, and told some of the things that prominent men have said about it.

Upon motion by Mr. D. C. Henny, the meeting adjourned.

ORRIN E. STANLEY, *Secretary.*

October 22, 1915, at 8:00 p. m., The Oregon Society of Engineers held a meeting in the main dining-room of the Commercial Club.

The meeting was called to order by President Turner, who introduced Mr. Henry Berger, Jr., and Mr. Frank Ives Jones, color photographer artists. Mr. Berger gave an illustrated lecture on "The Columbia Highway, Crater Lake, and the Snow-Capped Mountains of Oregon," while Mr. Jones operated the stereopticon. On hundred and seventy-eight pictures were shown, and the seating capacity of the room (400) was taxed, to accommodate the enthusiastic audience.

At the close of the lecture which lasted for more than an hour, the following motion by Mr. Vorse was carried: "Moved,—that the Society and its patrons record a vote of thanks to Mr. Henry Berger, Jr., and Mr. Frank Ives Jones for their great kindness in exhibiting their art, and to the Portland Commercial Club for contributing the use of their rooms for our convenience and pleasure."

The president urged members and guests to tarry a while and mingle socially.

The meeting adjourned at 9:25 p. m.

H. L. Vorse, *Secretary pro tem.*